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finish

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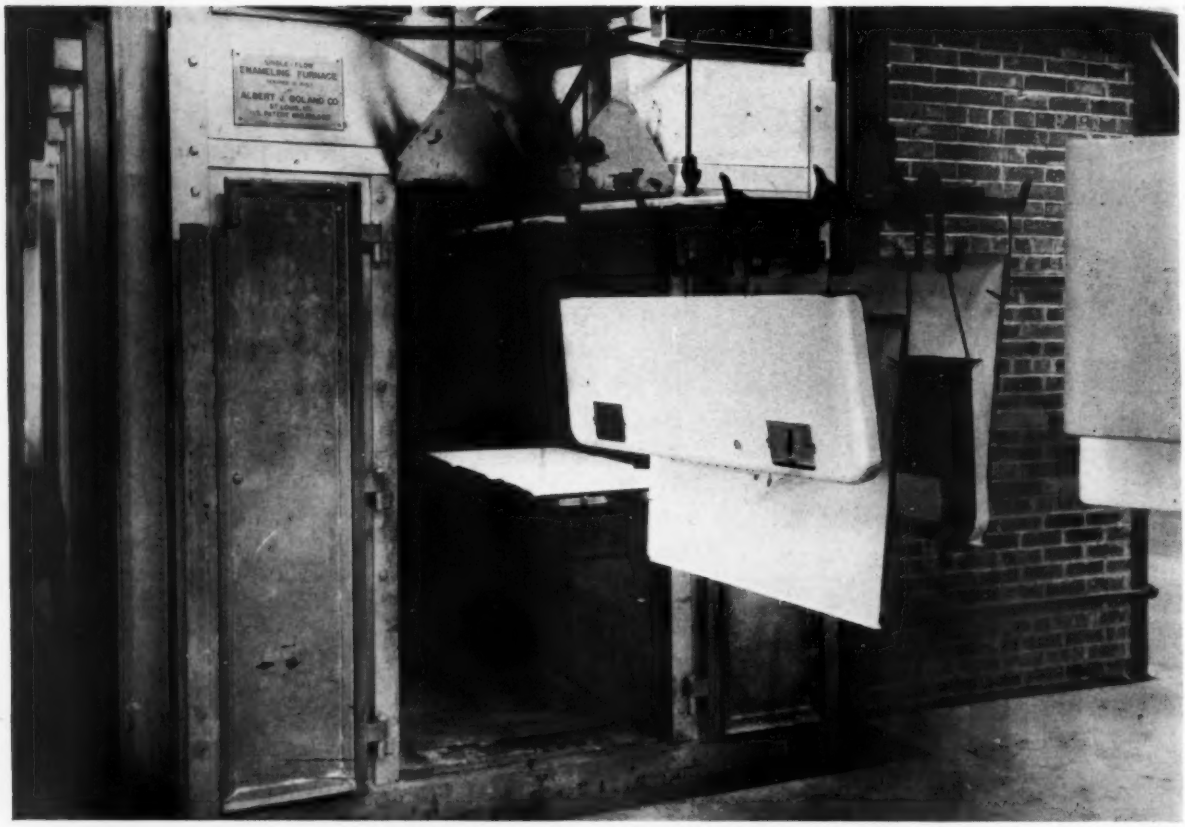
finish

CERAMIC FINISHES ON METAL



A Boland continuous furnace at Estate Heatrola Division, Noma Electric Corporation, Hamilton, Ohio.

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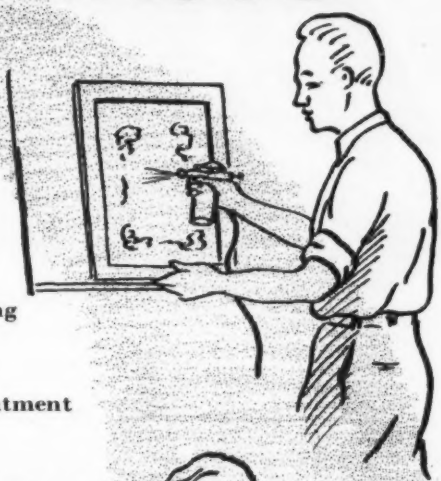

There is almost no limit to the number of permanent, colorful, decorative effects that may be easily and economically obtained with Porcelain Enamel.

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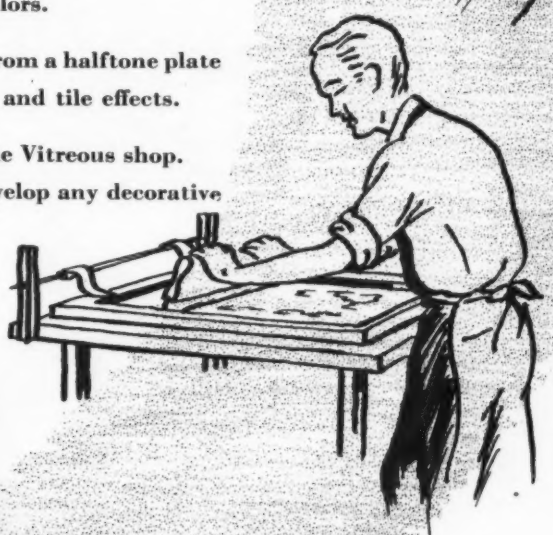
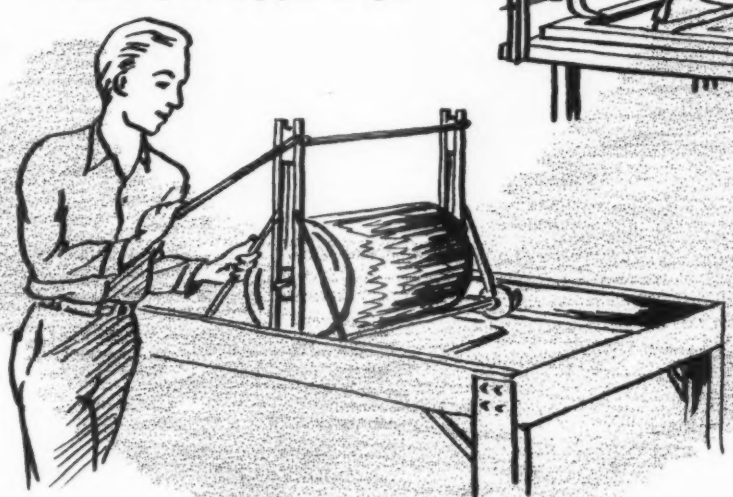
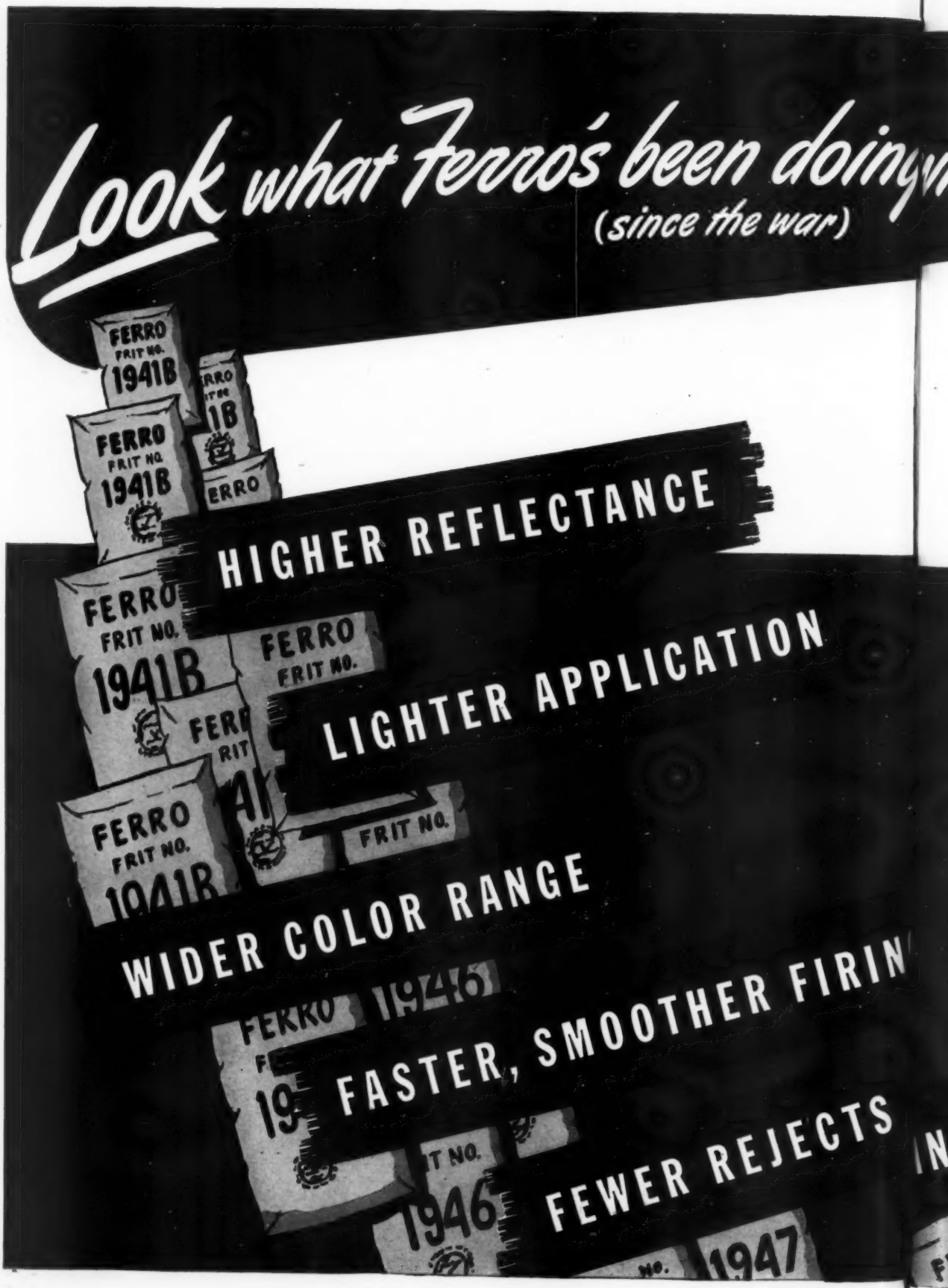




VITREOUS STEEL PRODUCTS CO.

BOX 1791, CLEVELAND 5, OHIO *(Factory at Nappanee, Ind.)*


Look what Ferro's been doing
(since the war)
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FASTER, SMOOTHER FIRIN
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Since their first commercial use in 1941 (as usual, these frits were extensively tested in various plants under production conditions before being generally publicized). Ferro Zircon Frits have become the most widely used cover-coat frits in the world. And with good reason.

Intensive Ferro research since the war, plus new production techniques, has made possible still higher reflectance . . . lighter application weights . . . wider color range (for matching whites) . . . faster, smoother firing . . . fewer rejects . . . finer overall appearance . . . better production, especially when used with Ferro High-Speed Groundcoats which fire at the same speeds and temperatures.

Yes, if you haven't kept yourself fully informed about what Ferro has been doing with Zircon Frits, we'd suggest you look into the matter. A letter or phone call will bring us running.

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BETTER PRODUCTION especially with HIGH-SPEED GROUND COATS

... with TONCAN ENAMELING IRON ... the metal that fabricates uniformly by every method—that welds readily—that always takes *and holds* a smooth, gleaming coat of vitreous porcelain enamel—that means satisfaction for your customers.

Toncan Enameling Iron starts *flat* and stays *flat,* even after repeated firings. When processed for *deep draws,* this top quality enameling sheet fills the die uniformly, faithfully reproducing every detail . . . it *flows* smoothly and evenly without wrinkling or cracking.

Remember: Toncan Enameling Iron is tailored to fit each particular type of product—tailored to keep production flowing, to increase product quality with fewer rejects and lower unit cost.

Put your enameling iron problems up to Republic's metallurgists. They know ceramics as well as metals.

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Almost unbelievable—yet its proved you can burn-off (degrease) and rust-proof in one operation. Tests prove infra-red rust-proofing more thoro than other methods. Hits all out-of-the-way corners. Finishing coats adhere perfectly. Proof is yours for the asking. Write immediately.

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THE Finish Line

SHOWMANSHIP is used by more and more companies and more and more industries to put over materials, products and basic ideas. Showmanship has *not* been used extensively in the porcelain enameling industry but that doesn't mean that it can't be used, and used effectively.

Displays are one medium

One effective medium where showmanship can be used is in the national shows and exhibits held periodically thruout the country to display industrial, commercial and household products.

As pointed out previously, the plastics, paints, synthetic finishes, bright metals, glass, wood and a myriad of products are usually there. With few exceptions porcelain enamel is conspicuous by its absence.

To make the most of these exhibits requires a sense of the dramatic. Porcelain enamel has many features of beauty, durability, fire resistance etc., that lend themselves to dramatization. Let's employ them!

Don't pass up possibilities

On page 22 of this issue of *finish* you will read the story of an auspicious dedication ceremony for a porcelain enameled air marker at Wheaton, Illinois. This comparatively simple project could well have been passed up with little notice — but — it wasn't.

The committee in charge of the new marker saw the possibility for using *showmanship* to get national attention for this much needed aid to non-scheduled flying. Invitations were extended to individuals who figure importantly in State and National flying organizations and a complete dedication program was planned.

As a result, air markers — *porcelain enameled air markers* — made the feature and editorial columns of large city newspapers and will get added attention in magazines and trade publications. The committee feels that the results were well worth the effort. Our industry can repeat this performance many, many times.

Do you follow the fire engines?

There are dramatic possibilities in FIRE that are hard to beat. Porcelain enamel is the one *fire-proof* finish — so why shouldn't we capitalize this point?

If we have to build a bonfire in a porcelain enameled house or filling station — sans furniture or equipment of course — to bring this life and property saving feature to the attention of architects, insurance companies and home owners, let's do it. Properly exploited, such a stunt *could* make the newsreels, newspapers and national magazines. And photographs could be used for endless educational purposes to put this story over.

The opportunities are manifold

Anyone connected with the industry can think of more and better examples of showmanship that could be used to advantage. We suggest that companies which derive their income from this durable finish, and organizations whose purpose it is to improve and promote it, give some thought to the possibilities — then plan a course of action.

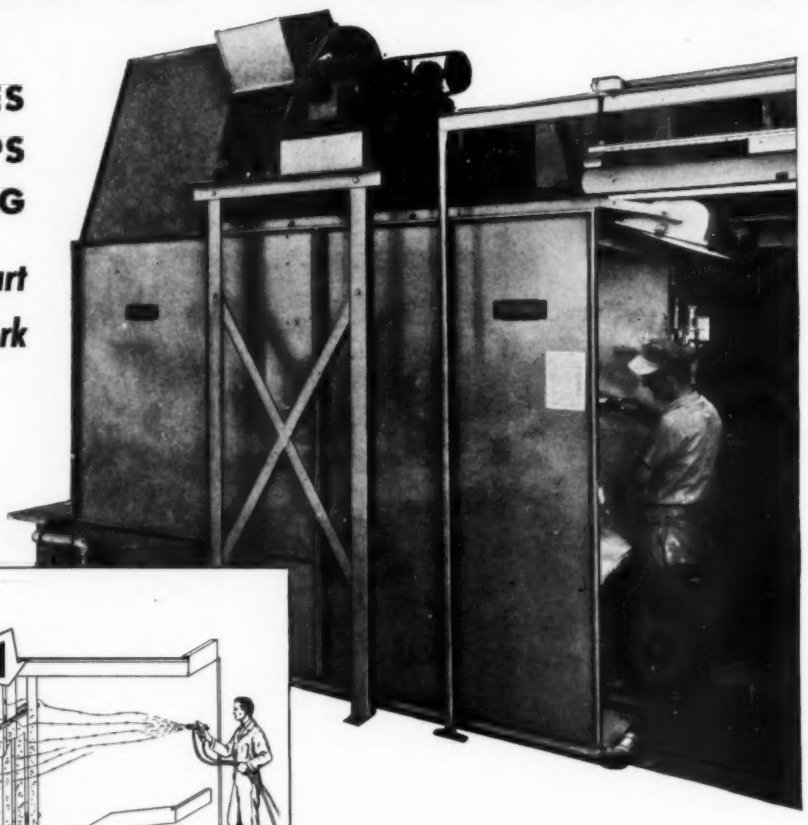
Dana Chase

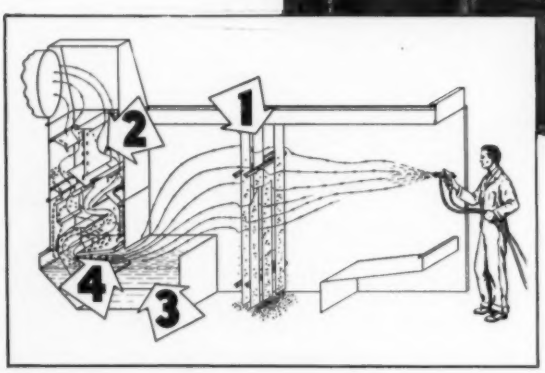
EDITOR AND PUBLISHER

The DeVILBISS

NO NOZZLES
NO PUMPS
NO PIPING

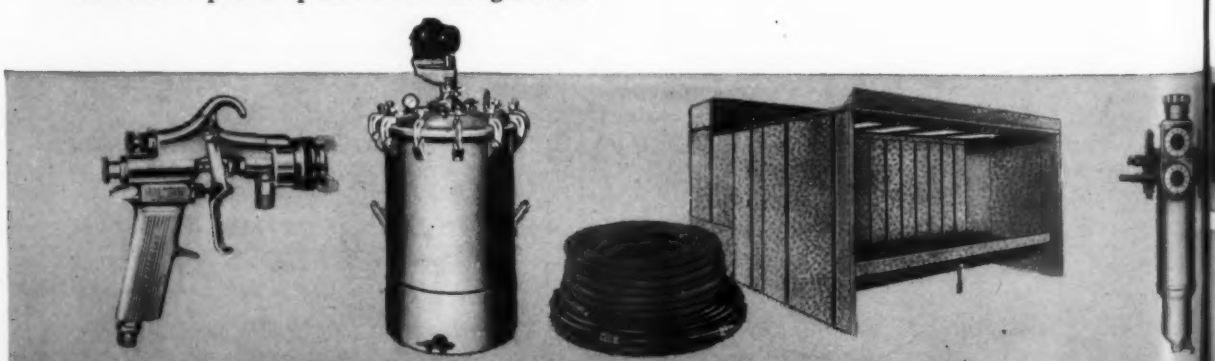
Only one moving part does all the work





1. Baffles arrest most of overspray in dry form.
2. Water-wash chamber removes balance of overspray.
3. Tank accumulates water precipitated solids.
4. Water is picked up here for centrifugal wash.

UP TO 99.3% OF OVERSPRAYED MATERIAL RECOVERED



A COMPLETE DeVILBISS LINE DESIGNED AND BUILT FOR PORCELAIN ENAMELING AND CERAMIC FINI

CENTRIFUGAL WATER-WASH SPRAY BOOTH

Saves its Cost in reclaimed material

Here is a revolutionary new DeVilbiss spray booth for porcelain enamel and ceramic finishing that actually pays for itself. Not only does *it recover up to 99.3% of over-sprayed solids*—it saves money because *it requires no maintenance.*

Only one moving part—the blower—does all the work and even its bearing is outside the exhaust duct. Nozzles, pumps, and piping, ordinarily subjected to severe abrasion, are entirely eliminated. There is nothing to wear out—nothing to require replacement or repair. Self-cleaning baffles replace eliminators and need never be removed. Static pressure always remains constant and consequently *the spray booth maintains a continuous exhaust efficiency never before equaled.*

Doors provide easy access to collection compartment in front of distributing plates and to the water wash chamber for quick removal of reclaimed material.

It will pay you to investigate the unusual features of this new DeVilbiss Centrifugal Water-Wash Spray Booth. It will pay you, too, to consult your DeVilbiss Engineer for information on every item in the complete ceramic line. There is no obligation, of course.

THE DEVILBISS COMPANY • TOLEDO 1, OHIO

Canadian Plant: WINDSOR, ONTARIO

DE VILBISS *means* **Quality** *in all four . .*

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- CERAMIC COLORS
- CHEMICALS
- BRONZE POWDERS
- METAL POWDERS
- SUPPLIES
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Our Technical Staff and Samples are available to you without obligation. Let us help you with your problems.

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…TTSBURGH 30, P…
Pacific Coast Agents
L. H. BUTCHER CO.

World's Most Complete Ceramic Supplier

Specialized enamel plant production— bathtubs and sinks

there is no magic or wonder-working equipment, yet the first ware pickled at 6:30 a. m. is finished and rolling into waiting freight cars at 8:30

By Harry B. Richardson

finish

Located in one of the oldest industrial areas in the entire United States, the Newark Enameling Corporation, Bloomfield, New Jersey, has successfully solved the problem of how to make a plant that is relatively small in area produce large volume of high grade ware.

Industrial giant neighbors, encroaching on property boundaries, allow no room for plant expansion such as would be possible in almost any Midwestern city. In consequence, the facilities that are available must be used to the highest possible degree of efficiency. Management and factory personnel have teamed up to make every inch of space and every movement count. Synchronized conveyors penetrate every nook and corner of the plant. Everything is transported by this means. A cardinal rule is that nothing whatsoever may be permitted to accumulate in corners. No discarded parts or surplus materials are set aside in unused places; there *are* no unused places.

Specialized enamel plant production — bathtubs and sinks

Production of stamped steel bathtubs in three sizes, and sinks in four sizes, is, of course, in white only. This permits concentration of effort and specialization of equipment. Stampings, received in carloads, are processed immediately without the necessity of carrying heavy inventories. The shipping program is keyed to receipts. It is interesting to observe that on Monday morning, pickling operations begin at 6:30. One-half hour later, the sprayers report for work. Furnace production begins within another half-hour; i. e., at 7:30. And just one hour later, at 8:30, the first production of the day has been inspected, crated and is rolling at a rapid rate into waiting freight cars to supply a much needed essential item for the relief of the acute housing shortage.

Earl Miller, head of this organization, together with his assistant, John Wynn, and a staff of hustling men, all of them surprisingly young and many of them "G. I.'s", have broken down every operation into a "combat team" job.

Multiple inspection points

The keenest emphasis is on inspection. At every strategic point an inspector is at work. Every stamping received gets keen scrutiny. Die marks, weld blisters, split steel, grease spots, and many other defects, are the cause of rejection. If the shape can be salvaged, it is done; if not, it never gets in process.

A welding crew takes over next. Supporting braces, strategically placed, are welded on the forms to provide rigidity during porcelain enameling operations. Hanger brackets are attached. An ingenious jig holds the tub in position while the "apron" is welded in place. Spot, arc, and acetylene processes are used. A small crew here starts off a flow of stampings, prodigous in volume for the apparent size of the plant.

A well planned, compact pickling room takes the production after it leaves welding. Standard procedure is followed and, after being thoroughly pickled and neutralized, the ware is delivered to the ground coat crew.

A "bathtub team"

On sink production, a "feeder" and two sprayers constitute a team. A "bathtub team" includes a third sprayer, as the backs of the bath tubs are sprayed in a separate booth located just ahead of the large ground coat spray booth. As indicated, all ground coat is sprayed, and the ware travels through a long booth at cable speed synchronized with the white spray booths and the furnace chain as well as carrying conveyors through-

Earl C. Miller, left, president, and John Wynn, superintendent, Newark Enameling Corporation.

LORD HALL LIBRARY

This welding operation is for the application of supporting members to the bath tub.

out the plant for smooth operation.

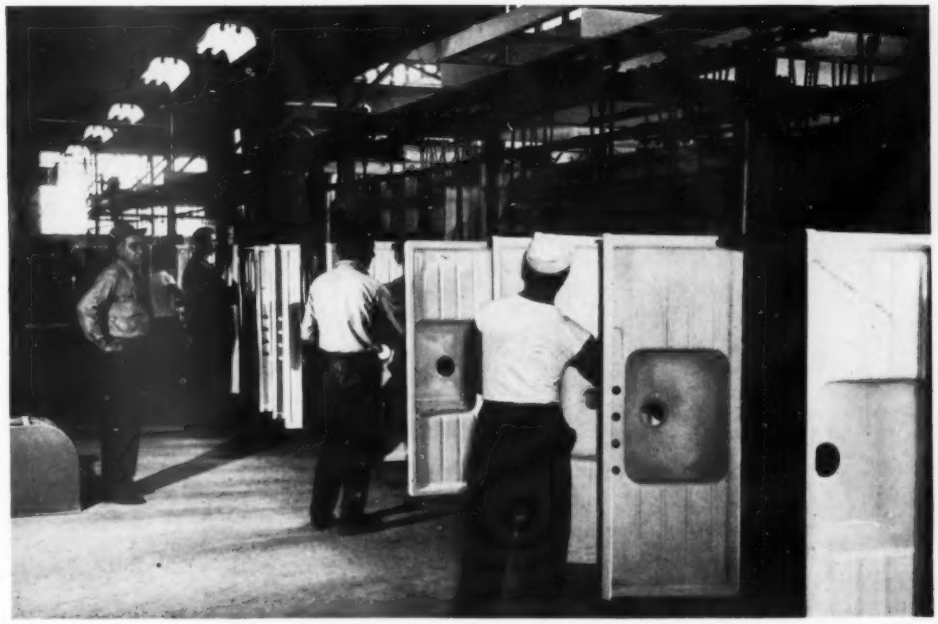
A gas-fired dryer delivers the ground coated ware to the furnace, just close enough for convenient transfer to the furnace carrier chain. Tubs, up to and including four and one-half feet in length, are suspended vertically. The furnace is a straight-away, single flow, with a 26-foot hot zone, serviced with six burners.

White spraying proceeds at a somewhat faster rate than ground coat, with similar equipment and methods being employed. Spray equipment includes multiple pressure tanks with agitators and magnetic separators. Tanks are mounted on skids, and empty tanks are quickly replaced by means of lift trucks. Replacement is a matter of minutes only.

Complete absence of dirt

There is a complete absence of dirt, and all spray dust, fumes, and residue are removed from the area in which the sprayer works. Waste enamel is precipitated in water. White is not reused, but reclaimed ground coat is used for spraying backs. The furnace carrier chain is loaded extremely close to theoretical capacity, with consequent high rate of production at low cost. Temperature control is closely regulated and recorded at three critical stages. A 28-foot cooling zone tempers the ware, which can be removed from the chain without discomfort before the loading zone is reached.

The well lighted spray line for applying cover coat enamels.



Method of hanging double drain board sinks on conveyor of continuous furnace.

Milled enamel is provided by one 1000 lb., two 800 lb., and three 400 lb. mills. Best practices are followed in this department. Rework is kept down to a percentage sufficiently low to satisfy a management that is very exacting on this point.

The company was founded some fourteen years ago by Earl C. Miller, together with Messrs. Frank Humpel and Louis Trebour, the two latter now retired. Mr. Miller is "chief" of the present activity. On the job, and overseeing every operation, is "Johnnie" Wynn with his staff of assistants, making the plant "tick." Nothing here is left to chance. Nobody "guesses so"; he knows definitely and specifically what the score is. It is quite apparent why the plant turns out a surprisingly large volume of superlative quality. The lesson this plant teaches is that mere size and elaborate equipment do not provide the answers. Here, there is no extensive amount of plant area. The personnel is not numerous. There is no magic or wonder-working equipment. But, production of high grade ware goes on — steadily, regularly, and without circus performances and razzle-dazzle.

The reason, in this observer's opinion, is that every step, in every operation, from bringing in the forms to the last final inspection and crating of the finished ware, is charted and supervised with closest attention to every small detail.

Inspection is most important in the production of sanitary ware.

Lithium compounds

in porcelain enamel compositions

By Dr. Paul A. Huppert • LISK MANUFACTURING CO., LTD., CANANDAIGUA, NEW YORK

Part I

Exclusive feature finish

I. Introduction

The purpose of this article is to review past work on the subject of lithium in enamels, and to present results of an investigation into the merits of certain new types of ground coat enamels. These enamels may be considered as new inasmuch as they depend largely upon the use of two recently developed compounds, lithium manganite and lithium cobaltite. These new compounds produce very definite effects on the enamels, as will be shown in this article.

The use of lithium-bearing raw materials in the enameling field is not new. Originally, lithia (Li_2O) was introduced into the batch formulae by means of one of the natural ores, amblygonite, lepidolite and spodumene.[1] The high cost of these minerals (on the basis of lithia content), as well as frequent variations in the chemical compositions of the ores and undesirable coloring impurities present, discouraged enamelers from extensive use in the past. In other ceramic products, such as special glasses and whiteware glazes, lithium carbonate has been successfully employed. The experience in enamels, however, appears to be different. Under certain circumstances, probably influenced by variations of the feldspar-quartz-borax contents, this material decomposes at different stages of smelting, before reaching the melting point of the frit, thus giving erratic results.

Recently, a number of new lithium compounds have been made available to the enamel industry. Some of the most interesting of these products are: lithium cobaltite, lithium manganite, lithium metasilicate, lithium molybdate, lithium titanate and lithium zirconate. Although these lithium compounds were relatively high in price, some of them seemed to offer such advantages that an investigation of their use in enamels appeared well worth-while.

Some chemical and physical characteristics of lithia

Lithium, Li, is the lightest metal known. Its atomic weight is 6.94, and it appears in the periodic system of elements as the first member in Group I, next to sodium and potassium. Many of its salts, however, tend to resemble salts of the alkaline earth metals in their chemical behavior.

Lithia, Li_2O, is the form to which lithium compounds usually convert in enamels on smelting. It is a very powerful flux, probably the most powerful yet known. Extremely small percentages will decrease both smelting and firing temperatures.

The coefficient of expansion of Li_2O, according to Winkelmann and Schott, is 2.0×10^{-7}, rather low compared to the oxides of sodium and potassium (10.0 and 8.5, respectively). Thus, it is claimed to be a valuable constituent in glasses with low thermal expansion. However, a very important investigation has been carried out by Louis Navias (Journal American Ceramic Society, *18*, 206-10 (1935)). While Winkelmann and Schott quote the coefficient of expansion of Li_2O as 2.0×10^{-7} — i.e., far lower than that of Na_2O and K_2O — measurements made on glasses containing lithia indicate that in respect to thermal expansion Li_2O is as effective as Na_2O in promoting high expansion.[2]

Waterton and Turner[3] determined the coefficient of expansion of Li_2O incorporated in certain glass formulas to be 4.9×10^{-7}.

F. C. Kracek (Journal Physik. Chem., 34, 2641-50 (1930)) presents a discussion on the binary system Li_2O-SiO_2 offering studies on equilibrium relations of the three compounds in the system; namely, Li_4SiO_4, Li_2SiO_3 and $Li_2Si_2O_5$.[4]

Many other references to investigations of lithium systems which are of interest to ceramists are to be found in the literature.

II. Historical survey

G. Nain (Ind. Chimique, *19*, 882-85 (1932)) describes the principal deposits of the world, the production of lithium, its use in the glass, porcelain and enameling industries, and its advantages by reducing viscosity, acting as a flux, lowering the coefficient of expansion, retarding devitrification, hardening the surface of the product.

Similar reports are given by V.C. (Verre and Silicates Ind., *6*, 281-82 (1935)).

Freitag (Emailwaren-Ind., 11, 249-50 (1934)) discusses briefly similar problems in the German industry. V. Charrin in France (Ceram. Verrerie. Email., *2*, 305-06 (1934)) shows that lithia reduces viscosity, produces a more corrosion-resistant glass, and also reduces thermal expansion. Waterton and Turner (Journal Society Glass Technology, *18*, 72 (1934)) report that introduction of lithia increased thermal expansion of certain glasses.

G. C. Betz (Journal American Ceramic Society, *21*, 189-91 (1938)) presents a comparison of the properties of lithium and the more common alkaline metals, sodium and potassium, with respect to ceramics. He, too, found its value to be in the reduction of the maturing temperature, as well as in the increase of fluidity and gloss.

Quite a few papers have been presented on the use of lithia as a flux in glasses, vitreous china, dinnerware glazes, etc., by N. J. Kreidl (Ceram. Abst., *20*, 273 (1941)), J. E. Ablard (Journal American Ceramic Society, *28*, 102, (1945)), H. J. Orlowski and John Marquis (ibid., *28*, 344-60, (1945)), John H. Voorlies (ibid., *28*, 170 (1945)), Bartlett & Thomas (ibid., *17* (1934)), and Reidel & Schaefer (Sklarski Rozhedy, "Influence of Lithia in Glass", *17*, 25028 (1940)).

Dr. W. E. S. Turner and his coworkers have published a number of papers dealing with the effect of lithia on glass compositions; viz., (a) Waterton & Turner, Ceramic Industry, "Properties of Mixed Alkali-Lime-Silica Glasses Containing Lithium" (October, 1935), (b) Howarth & Turner, Journal Society of Glass Technology, "Dissociation of Lithium Carbonate and Potassium Carbonate", *15* (1931), (c) Turner & Preston, Journal Society Glass Technology, "Volatilization of Lithia at High Temperatures from Li_2O-SiO_2 Glasses", *18* (1934).

While papers on both theoretical considerations and practical applications of lithia in the field of porcelain enamels have been few in number, some very significant conclusions have been arrived at in those papers which have been published. For example, G. H. McIntyre (Chemical Industries, *42* (May 1938)) recommended the use of lithia to obtain a high coefficient of expansion in enamels.

In his study of "Molybdenum in Enamels", Karl Kautz[5] included in his investigations experiments with lithium molybdate and found that by adding this water soluble lithium compound to the mill batch, decided improvement in adherence of light colored ground coat enamels was evident.

Examples of Formulae Containing Conventional Lithium Compounds

	Low Burning Ground Coat	Low Acid Resisting White	Antimony Free White	A.R. White	Super-Opaque White
Feldspar	29.7	21.2	23.2	9.5	12.5
Borax	33.6	21.4	24.2	18.0	22.9
Quartz	17.8	19.6	23.2	39.0	23.5
Soda Ash	3.95	5.6	3.05	5.0	6.7
Sodium Nitrate	3.95	2.8	3.95	3.0	3.0
Fluorspar	4.95	3.15	—	1.5	2.5
Sodium Silicofluoride	—	—	18.9	5.0	—
Cryolite	—	9.3	—	—	8.4
Kaolin	—	—	1.9	—	—
Bone Ash	—	—	—	1.5	—
Zinc Oxide	—	3.15	—	—	2.9
Titanium Oxide	—	—	—	3.0	—
Sodium Meta-antimonate	—	6.3	—	9.5	12.6
Lithium Carbonate	3.95	7.4	1.5	5.0	5.0
Cobalt Oxide	.5	—	—	—	—
Nickel Oxide	.5	—	—	—	—
Manganese Dioxide	1.1	—	—	—	—

More recently, Kautz (Journal American Ceramic Society, *3*, 77 (1945)) refers to very low maturing lead and lithium-containing clear enamels. One of the formulas is as follows:

(a) Empirical formula:

.85 PbO
.05 ZnO
.05 CaF_2
.05 Li_2O
} .25 B_2O_3 ... .30 SiO_2

(b) Smelter batch:

Litharge	75.80
Zinc Oxide	1.60
Fluorite	1.54
Lithium Carbonate	1.46
Quartz	7.20
Boric Acid	12.40

Addition of 4% to 8% molybdenum trioxide is optional

An interesting paper has been presented by L. Vielhaber (Emailwaren Ind., *11*, 250 (1934)) in which he states that lithium oxide has no opacifying effect nor can it be used as an adhering oxide. It does, however, act as a flux. Light ground coat enamel can be produced, and as a good example he quotes the following formula:

Borax	34.6
Feldspar	23.3
Quartz	19.6
Sodium Nitrate	1.55
Soda Ash	6.9
Calcite	3.15
Fluorspar	3.15
Lithium Carbonate	7.75

with a mill addition of 10% clay and 8% quartz

H. F. Staley (Journal American Ceramic Society, *4* (September, 1921)) found that while lithia was unsatisfactory for developing acid resistance in dry process enamels, it did increase the acid resistance of wet process enamels.

More recent work was reported by Marvin O. Lewis (Journal American Ceramic Society, *26* (1943)) in his "Effects of Lithia Substituted for Soda in Vitreous Enamel." In this investigation, the author started with a conventional white cover coat and substituted lithium carbonate for the sodium carbonate. Lewis's conclusions were to the effect that mol replacement of lithia for soda resulted in improved fusibility, gloss and opacity, higher gouge, surface abrasion and acid resistance, and in lower thermal coefficient. Weight replacement resulted in increased fusibility and gloss, a small decrease in surface abrasion resistance, marked decrease in opacity and gouge resistance, little change in thermal expansion coefficient, and a noticeable lowering of the transformation temperature.

Patents on lithium in enamels

Ludwig Stuckert, author of "Die Emailfabrikation"[6] in which work he does not yet refer to the use of lithium except for the mention of lepidolite, was granted U. S. Patent No. 2209585 (July 30, 1940) on "acid resisting enamels". One object of the claims of his invention is the attainment of acid resisting enamels without destroying the luster of the finished enamels, or without decreasing fusibility of the enamel composition. This effect is accomplished by

the substitution of lithium oxide for a part of the alkaline metal oxide present in his improved composition. A sample batch formula of such a borax-free enamel was quoted as follows:

Batch formula

Feldspar	13.1
Soda Ash	27.7
Calcspar	10.5
Zinc Oxide	.8
Lithium Carbonate	2.1
Quartz	45.5

Oxide composition

Na_2O	20.3
K_2O	1.1
Li_2O	1.1
CaO	7.2
ZnO	1.1
Al_2O_3	2.7
SiO_2	66.5

Calculated coefficient of expansion of this formula = 319.6 x 10^{-7}

Another American Patent, No. 1443813, proposes the use of lepidolite which has a melting point of about 1700° F. compared to feldspar with about 1950° to 2000° F.

A more recent patent on "lead free enamels" has been granted to Alden J. Deyrup (No. 2352425 — June 27, 1944) in which quite a number of batch formulae are quoted, containing from 2.5% to 10.9% lithia, introduced into the batch as lithium carbonate, with the claim that these lead-free enamels mature below about 1150° F.

White Coat Based on Use of Amblygonite

Borax Anhydrous	9.2
Quartz	30.2
Soda Ash	12.6
Sodium Silicofluoride	5.9
Fluorspar	9.4
Titanium Oxide	6.0
Amblygonite	2.2
Soda Nitrate	4.7
Zircon	14.7
Topaz	4.7

III. Experimental study of effect of lithium manganite and lithium cobaltite on ground coats.

With the advent of the two new compounds, lithium manganite and lithium cobaltite, experimental frits were prepared, using a range of lithium manganite of from 1.0% to 3.5%, with and without lithium cobaltite. From this initial work, formulae have been selected for purpose of illustration.

Examples of New Lithium Ground Coat Compositions

Formula	*No. 14*	*No. ST-1*	*No. ST-4*
Quartz	31.2%	29.8%	29.8%
Feldspar	23.2	21.5	21.6
Borax Anhydrous	20.1	25.6	25.7
Soda Ash	11.6	9.2	9.2
Sodium Nitrate	6.55	5.1	5.1
Fluorspar	6.05	6.2	6.2
Lithium Manganite	1.01	1.5	1.5
Nickel Oxide	.1	.6	.6
Cobalt Oxide	—	.5	—
Lithium Cobaltite	.2	—	.3
Melted Oxide Composition			
Na_2O	18.0	17.3	17.3
K_2O	1.75	1.58	1.59
Li_2O	.31	.39	.45
CaF_2	6.7	6.7	6.7
B_2O_3	15.35	19.20	19.20
Al_2O_3	4.48	4.05	4.07
SiO_2	52.50	48.6	48.7
MnO_2	.73	1.05	1.05
NiO	.11	.65	.65
CoO	.18	.51	.26
Calculated Coefficient of Expansion			
	281.0	272.1	271.4

Analysis of Feldspar used in above formulae:

K_2O	6.8%
Na_2O	4.0
Al_2O_3	17.4
SiO_2	70.6

Fluorspar = 100% CaF_2
Lithium Cobaltite = 15.0% Li_2O
Lithium Manganite = 24.0% Li_2O; 64.7% MnO_2

COURTESY METALLOY CORPORATION, MINNEAPOLIS, MINNESOTA

Lithium Manganite

Smelting

The smelting of two frits of exactly the same composition, except for manganese, was closely watched under similar smelter conditions. Frit A contained 2.1% manganese dioxide, while in frit B the manganese dioxide was replaced with the same amount (in weight) of lithium manganite with no other alteration. The result was as follows:

Ground Coat Frit	Total time for charging, smelting and discharging	Time for charging & smelting	Time for discharging
A — with MnO_2	2 hrs. 27 min.	2 hr. 14 min.	13 min.
B — with Li_2MnO_3	2 hrs. 7 min.	1 hr. 56 min.	11 min.
Decrease in time	20 min.	18 min.	2 min.

The comparison of the results shows not only a decrease of the smelting time of about 13%, which figure also includes the charging of the smelter, but also a decrease of more than 15% of the time needed for letting the frit run out of the smelter. This fact signifies distinctly the influence of the lithium manganite on fluxability and viscosity.

The latter fact has also been proved by the flow button test, in which the enamel corresponding to formula B, with lithium manganite, flowed 2½", while the other one, according to formula A, with the manganese dioxide, flowed 1¾". This test indicates a decided difference in hardness, fluxability, and viscosity.

According to information obtained from the manufacturer of the lithium manganite, this material has proved stable, undergoing no oxygen loss when heated up to 2000° F. for two hours, both in air and in an inert

atmosphere. This is in contrast to manganese dioxide which on heating in air loses some oxygen between 900° and 1100° F., and which is transformed into Mn_3O_4 at about 2000° F.

This property of the lithium manganite might be partly the explanation of the behavior of the lithium manganite-bearing frits in the smelter, but it might also be responsible for certain other characteristics of such frits.

Application

When dipping lithium manganite bearing enamels, no difference in the general workability was noticed. After some initial experimenting, however, it was found that a reduction in specific gravity as well as in the pickup could be accomplished which had no unfavorable influence on the final results. While a reduction in the specific gravity from about 1.66 to 1.58 grams was possible, the pickup test on a one foot double surface cylinder (wet weight) could simultaneously be reduced, under otherwise unchanged conditions, from an average of 136 grams to an average of 106 grams. Thus, the average thickness of the ground coat enamels, measured with a G.E. thickness gauge, had been reduced from .004 to .005" to about .002 to .003", corresponding to about 30 to 40%. These figures have also been confirmed by checking the amount of enamels consumed per month before and after introducing lithium into the ground coats. Therefore, even an initial increase of the costs of material did not show up when calculating the final costs of enamels per number of pieces (or square feet of ware) produced. The lower viscosity and surface tension might be the causes leading to thinner application.

Firing

When first firing lithium bearing ground coats, the same firing temperature and time was maintained as for the corresponding non-lithium bearing enamels. In spite of thinner coating, the lithium-bearing enamels withstood relatively well the firing temperature of 1575 to 1580° F. Burning off was rarely noticed, and if so only on edges and spots where the coverage, due to uneven application, dropped far too low. Soon, however, it was found that a reduction of the firing temperature was possible without affecting the quality of the bond. When replacing MnO_2 with Li_2MnO_3, weight by weight, the proper firing temperature was fixed at 1540° F., corresponding to the firing temperature of cover coat, without changing the speed of the chain; i.e., the firing time.

A further drop in the firing temperature was possible by increasing the addition of lithium manganite by another 1½%. This enamel, however, became so soft that the finish coat, when applied over it, lost its smooth surface texture and became wavy. Apparently the ground coat, if too soft, starts to melt slightly (or to soften up) underneath the cover coat during the finish firing. The optimum conditions, therefore, on the special ground coat formula, on which the initial experimenting had been based, were reached by an equal replacement on a percentage basis of lithium manganite for manganese dioxide. This is, however, only true for certain frit compositions. When non-lithium formulae differing from those referred to in this paper are employed, it is probable that a certain amount of experimenting will be necessary to determine the correct percentage of lithium manganite for best results.

From the results obtained, it can be deducted that an addition of about 2% lithium manganite will reduce the firing temperature up to 50° F., at the same time permitting a wider range of firing temperature but still obtaining a good bond.

Influence of lithium on ground coat properties

The introduction of lithium manganite as indicated previously did not result in reboiling, nor did it create any copperheading, shiners, or fishscale. As it seemed, on the contrary, that lithium compounds might even exert a favorable influence on the elimination of ground coat defects, a special experiment was run. First, the content of adherent oxides in a given ground coat composition was reduced to a minimum. The frit containing originally 3.6% total of adherent oxides — i.e., cobalt oxide, nickel oxide, and manganese dioxide — was smelted with only 1.25%:

.95% Manganese Dioxide
.15% Cobalt Oxide
.15% Nickel Oxide

With this ground coat composition, it has been possible to artificially produce fishscale and shiners on steel of gauge No. 23. One mill was ground extremely fine, to .9 gram residue on 200 mesh sieve of a 100 gram sample according to P.E.I. fineness test, resulting in very fine shiners, while another mill ground coarser, with a residue of 3.7 grams under the same test procedure, produced small fishscales.

The next sample was run with the same frit, low in adherence oxides, under equal conditions, but with an

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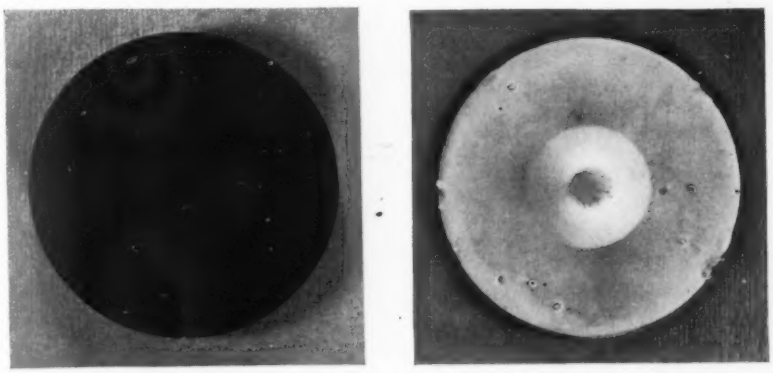

Illustrated are the results of "falling weight" tests for adherence of a lithium bearing ground coat and a one coat white cover coat over a lithium ground coat.

Porcelain enameled air marker

gets national attention

THE dedication of one of the country's first all-porcelain enameled air markers, at Wheaton, Illinois, Sunday, May 4, was a two-fold accomplishment.

First, it offered for the convenience and safety of an ever-increasing number of aerial enthusiasts what is said to be the first such permanent identifying air marker in Illinois.

Second, and most important to the enameling industry, it opened a promising new market for porcelain enamel.

The new air marker has already won state and national attention as a result of participation in the dedication ceremonies by state and national air marking authorities. Creditable descriptive stories were carried in both Chicago and suburban newspapers.

A cooperative project

As previously outlined in *finish (see May, 1947, issue)*, the new porcelain enameled marker was a cooperative project suggested by C.A.P. Squadron 611-2, and initiated by *finish* through a published challenge to the porcelain enameling industry.

The necessary engineering and enameling services, together with the necessary steel, frit and colors, were offered by participating companies in order to make possible the installation of a porcelain enameled marker that will lead the way to safer air travel for non-scheduled flights and open a new market for porcelain enameled steel.

From the air

From 12 o'clock until two on the day of the dedication ceremonies, visiting officials, sponsors and guests were provided the opportunity of viewing the new marker "from above."

Your editor had the privilege of viewing the marker from a Stinson four-seater, piloted by Fred Wardle, president of the Air Power Club of Du Page County. Such is the reflecting quality of the porcelain enameled letters that the sign can be read clearly at several thousand feet, and, with the main section of the sign being mounted on a black roof, the letters give an impression of being "raised" from the roof surface.

An auspicious ceremony

The dedication ceremony contained all the frills, including band music, formation flying by military planes, speeches by leading air marking authorities, and messages from the Governor, Chicago's Mayor and an acceptance speech by the Mayor of Wheaton.

Chairman of the speakers program was Major M. J. Lucas, commander, Du Page Squadron, Civil Air Patrol.

Excerpts from principal speeches

M. J. Lucas, in opening the ceremony, said, "It goes without saying that every one who had either a close or remote part in the placing of this air marker, and in dedicating it today, are quite proud of the fact that we are associated with the project."

Lt. G. M. Glidden, of the Air Power Club of Du Page County, and chairman of the Air Marker Committee, presented the history of the

finishfoto

The speakers' platform at the dedication ceremonies. Left to right, seated: Lt. Col. G. A. DeCosta, Lucy Kalla, Blanche Noyes, Mayor W. A. Gammon, Robert Dewey, Lt. Col. Charles Richardson, Major M. J. Lucas, Capt. Paul H. Dunakin, L. Joe Bolles, and E. L. Seasholtz. Left to right, standing: Arthur Karstens, Capt. Ronald Smith, unidentified, George Petru, James M. White, H. Jackson Burt, Frank L. L. Wilson, Capt. George Dunlap, Fred H. Wardle, Fred Vallette, O. B. Dold, Dana Chase, Arthur Atwater, Howard Michel, Ralph Foraker, and Galen M. Glidden.

PHOTO COURTESY PAUL H. DUNAKIN, JR.

project. He said: "Back in 1944 the Civil Air Patrol in Du Page County had a number of projects for training their pilots and observers, and included was the problem of determining the one best place for an air marker in the county. The highway department supplied maps, which were then sectionalized. Then followed an intensive search which resulted in the determination that the present marker location is the best in the county. . . . Dana Chase wrote an article in his magazine, *finish*, as a challenge to the porcelain enameling industry, saying 'Here's your chance.' The enameling industry took this challenge and as a result we have an air marker . . . here in Wheaton . . . It has only ten different sections to make up the letters of the alphabet.

"The manufacturers have supplied the material so that this test sign was made available at practically no cost to the City of Wheaton. We are definitely indebted to the people who produced the sign, the magazine *finish* who followed through, and the Lions Club for their installation."

L. J. Bolles, of American Rolling Mill Company, spoke for the four cooperating companies in dedicating the sign to the City of Wheaton. Said Mr. Bolles: "We have been very much interested in the progress of this sign because of the familiarity it is going to give people who fly over the length and breadth of this land — which they must have to propel new aviation progress . . . The more familiar you can make Wheaton and the towns around here, and get your airports on the map, the more visitors you're going to have and the more happiness you are going to give the wayward aviator who can't find his way — and we have all been there many, many times. . . . It is amazing how anything looks different when you are thrown into a different situation, and yet the most familiar thing is a good sign — whether it is on a highway, a street corner, or on the roof of a building such as the very excellent job you have done here. . . .

"The companies who were behind this idea include: Porcelain Enamel Specialties Company, of Baltimore, Maryland (design); American Rolling Mill Company, Middletown, Ohio (steel); Pemco Corporation, of Baltimore (frit and colors); and J. M. Seasholtz and Sons, Inc., Reading, Pa. (fabricating and enameling).

"We hope this is just one of many, not only because it means a new type of business for manufacturers, but also because it means air progress in these United States. On behalf of the manufacturers, and in the interest of aviation progress, we present this sign to the citizens of Wheaton."

Capt. Paul H. Dunakin, executive officer of C.A.P., made the presen-

Bolles, Foraker, Seasholtz & Michel inspect marker.

Gladys Snyder

Lt. Col. DeCosta

Dana Chase greets Blanche Noyes.

Fred Wardle

Glidden speaking— Dewey at extreme right.

Workmen putting the finishing touches on the numerical section of the new porcelain enameled air marker. Numerals are 10' high; letters, 15'.

tation for the Civil Air Patrol, in which he said: "C.A.P. is a nation-wide organization which is an auxiliary of the Army Air Forces, and particularly on behalf of the Du Page Squadron of C.A.P., it is my pleasure to thank the donors of this sign and, also, to thank the magazine, *finish*, all of whom have contributed so greatly to the effecting of the sign. It has done a great deal to put Wheaton on the air map. . . . We are happy to present this air marker to the City, and, in so doing, hope that this marker, which can be furnished in pre-fabricated, packaged form for permanent installation, will encourage other communities throughout the country to properly air mark their areas, thereby furthering safe flying and materially assisting in the building of a strong auxiliary defense for this great land of ours."

Fred Wardle made the presentation for the Air Power Club, of Du Page County, which was formed by a group of fliers and non-flying people interested in aviation from all angles. Said Mr. Wardle: "We joined with the Du Page Squadron of C.A.P. and the Lions Club in the promotion and installation of this marker. To the best of our knowledge, it is the only marker of its kind in this country. *Wheaton is spelled in letters 15' high. Numerals are 10'. The entire sign is 240' long. The numerals 4152 mean 41 degrees 52 minutes north latitude. The 8806 represents 88 degrees 06 minutes west longitude. . . . The large arrow between the numerals points north, while the arrow with the circle gives the direction of the nearest airport four miles away.*

"The sign is in accordance with the specifications of the C.A.A., and the proper steps have been taken so that the air marker may be put on the Airmen's map when the program is inaugurated.

"It is the sincere desire of the Air Power Club and the Civil Air Patrol that similar installations can be made in all prominent spots in Du Page County, for they are as important to our private fliers or airmen as the sign posts are to the auto driver."

A. T. Eddy made the presentation for the Wheaton Lions Club, of which he is president. He said: "I think I speak for every member of our Club when I say that we are happy that we have had a part in the installation of this sign."

W. A. Gammon, mayor of Wheaton, accepted the sign for the city with the following words: "It's a very fine thing for our city. About two years ago I had the pleasure of meeting with the Civil Air Patrol in Elmhurst, and at that time they talked about this sign that they were thinking of putting up. The marker was then only a dream — today it is a reality. Some one must always dream to bring about improvements.

"It was my pleasure this morning to take a trip with Captain Dunakin in his airplane to look at this marker. As has been stated, it is a very fine thing for our city."

Robert Dewey, director of the Department of Aeronautics for the State of Illinois, which is responsible for the establishing of air markers for the state, was strong in his commendation of the project. He said: *"I think without a doubt it's the finest air marker in the State of Illinois and possibly, and probably, the finest in the country today.* The people of Wheaton and the various organizations have certainly shown a pioneering spirit in this air marking business. They have set an example which I sincerely hope, and confidently feel, the other communities of this state as well as communities of the whole country will follow. I don't think we can have too many air markers. . . .

"As far as the State of Illinois is concerned, I assure you that the Department of Aeronautics will do its share, or more than its share, in providing the air markers for the pilots of this state. We plan a program as soon as possible, and one of the important things that has been under consideration in making up our program is finding out the best type of sign. . . . "

Blanche Noyes, director of air marking activities for the Civil Aeronautics Administration, Washington,

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Porcelain enameled restaurant

proves eminently satisfactory

WHILE motoring along Route 50 in Southern Ohio, an unusually attractive small roadside restaurant caught our attention. We immediately recognized it as an installation that had been pictured earlier in *finish*.

The location of this inviting drive-in restaurant is Mariemont (suburban Cincinnati). It is the property of Mr. D. Frisch, experienced restaurant operator. This all-steel building has porcelain enameled exterior, painted interior, and is thoroughly insulated. Construction was by Globe Wernicke. Architectural porcelain enamel was supplied by W. A. Barrows Porcelain Enamel Company.

The installation was made in 1940, and now, after seven years of use, still presents an inviting appearance to both local and cross-country motorists.

Mr. Frisch is most enthusiastic about porcelain enamel as a finish. Based on experience with his first porcelain enameled building, Mr. Frisch had constructive suggestions to make. A double entrance was not provided in the original installation, and had to be added later for winter weather. The curbs of the parking area were not of sufficient height and, as a result, on two different occasions cars rolled over the curb and damaged building panels. These were replaced, without difficulty, and no one, aside from Mr. Frisch, would know of the accident. This problem is easily handled by providing curbs of sufficient height.

Said Mr. Frisch: "I am planning a chain of restaurants of this type to be located along Route 50. Future buildings, granted that materials are available, will be porcelain enameled *both inside and outside*. I have to paint the interior of the restaurant twice each year in order to keep its appearance on a par with the exterior. In the seven years that this installation has been in use, a good washing twice a year has been sufficient for the exterior, in spite of the fact that there is considerable atmospheric dirt in this locality."

Mr. Frisch stated further that he had received from customers "all kinds" of inquiries relating to the building material used, and that in many instances those inquiring were from distant sections of the country.

This drive-in restaurant has an attractive airplane sign depicting a "Mainliner" for which the restaurant is named. The porcelain enameled sign has a maroon background with a cream colored airplane outlined in neon. A transluscent circular section at the bottom of the sign shows the picture of an airlines hostess.

This is offered as a typical example of the results that may be expected from the satisfactory installation of a well designed porcelain enameled building. Not only will this restaurant owner build multiple units, but the thousands of people who view the building year after year will add many new prospects to an already growing industry-customer list.

Over eighteen hundred attend

the American Ceramic Society 49th annual meeting

50th annual meeting to be held in Chicago

THE Traymore Hotel, in Atlantic City, was the official headquarters for the 49th annual meeting of the American Ceramic Society, with other hotels cooperating to house the record-breaking attendance.

Charles S. Pearce, A.C.S. general secretary, photographed with the new officers: W. E. Cramer, John D. Sullivan and J. W. Whittemore.

A new feature at the Convention was a daily publication carrying the registration list—Ceramic Age Daily. This publication reported in its Thursday edition a registration topping 1800. Attendance was excellent at the many division meetings held at Convention Hall.

Sullivan heads slate of new officers

John D. Sullivan, Battelle Memorial Institute, Columbus, Ohio, heads the slate of new officers as president for the coming year. J. W. Whittemore, Virginia Polytechnic Institute, Blacksburg, Va., is vice president; and W. E. Cramer, Industrial Ceramic Products, Inc., Columbus, Ohio, is treasurer. Charles S. Pearce continues as general secretary.

Official personnel of the Enamel Division includes: F. R. Porter, trustee; J. J. Canfield, chairman; D. G. Moore, vice chairman; and F. A. Petersen, secretary. *(See Enamel Division report for detailed information.)*

Official personnel of the Materials and Equipment Division includes: E. M. Rupp, Columbus, Ohio, trustee; W. E. Dougherty, O. Hommel Company, Pittsburgh, Pa., chairman; W. E. Williams, Ceramic Supply Co., Crooksville, Ohio, vice chairman; and G. C. Betz, Metal & Thermit Corporation, New York, New York, secretary.

Official personnel of the Refractories Division includes: L. C. Hewitt, Laclede-Christy Clay Products Co., St. Louis, Mo., trustee; C. A. Freeman, A. P. Green Fire Brick Co., Mexico, Mo., chairman; C. L. Norton, Jr., Babcock & Wilcox Co., New York, N.Y., vice chairman; and E. C. Petrie, North American Refractories Co., Cleveland, Ohio, secretary.

Social activities well attended

The auditorium, in which the Grand Entertainment and Boardwalk Night were held on Tuesday evening, was packed on both the main floor and balcony to see and hear well selected entertainment.

As usual, the highlight of the entertainment features was the banquet meeting on Wednesday evening, in the American Room at the Traymore Hotel. Announcement was made early on Wednesday that all but a handful of available tickets had been sold at that time.

A goodly number of ladies attended the convention, and a complete ladies' social program was planned for them.

Heavy schedule of technical papers

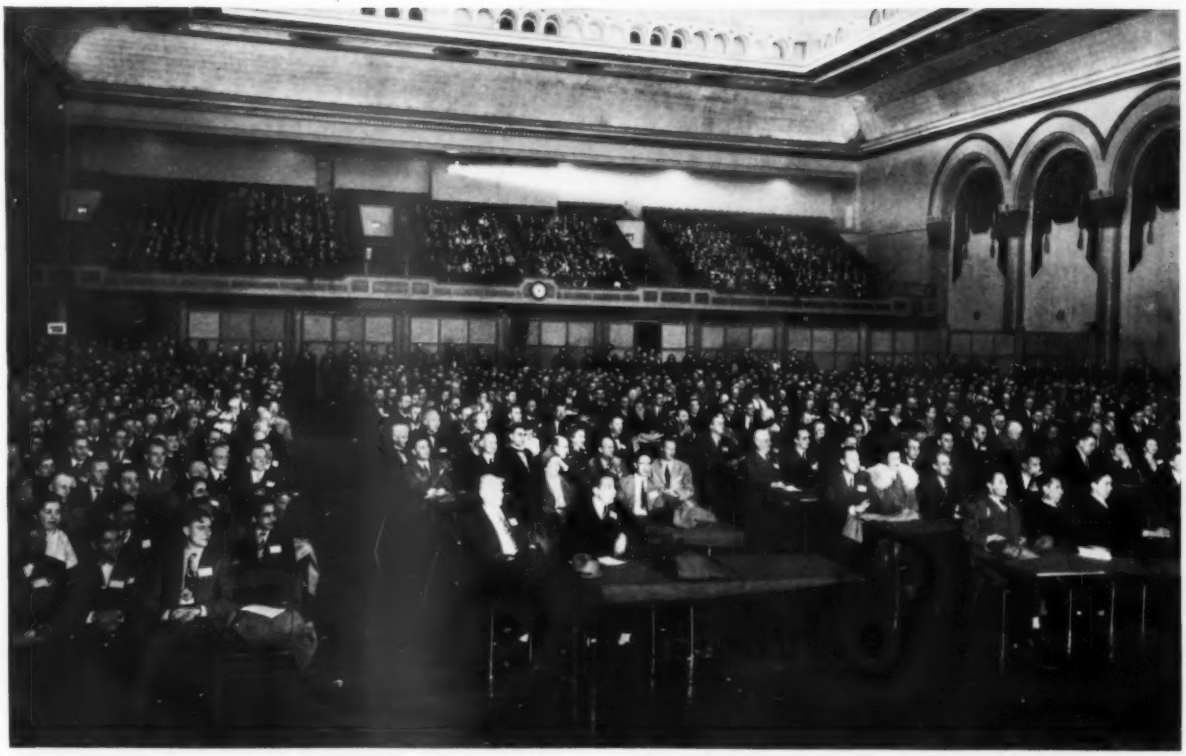
Division meetings started Tuesday afternoon, and carried well through Thursday, due to the heavy schedule of papers in practically all divisions. In the Enamel Division, for instance, full time of two and one-half days was required to complete the papers scheduled. The papers covered a wide variety of subjects, and the vast majority were well illustrated.

Congratulations were in order for Charles Pearce and the Division Chairmen for a well rounded and worthy program.

Chicago to get convention in '48

It was reported that the American Ceramic Society Convention in 1948 will be held in Chicago, with headquarters at the Palmer House. It is expected that the Enamel Division will get an unusually heavy attendance next year due to the central location selected for the meeting.

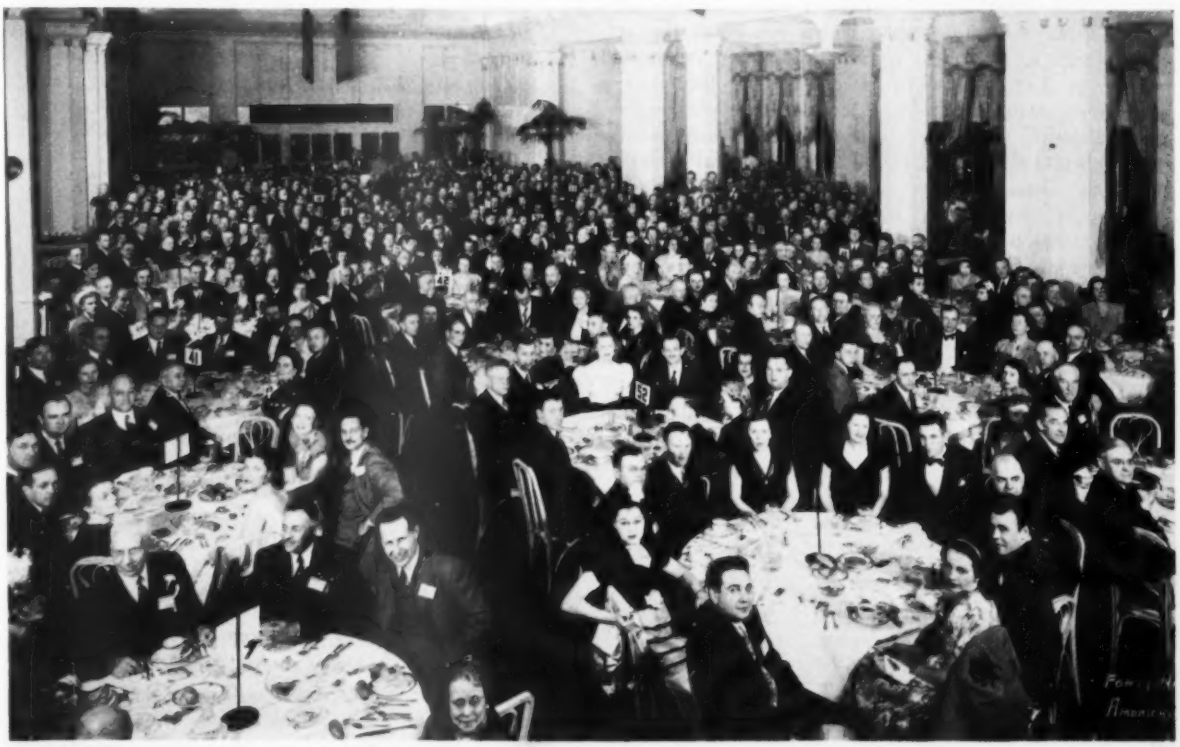
We'll see you in Chicago in 1948



This photograph gives some conception of the attendance at general session meetings which formed a part of the extensive program at the Atlantic City convention of the American Ceramic Society.

PHOTOGRAPHS BY FRED HESS & SON

Highlight of the social activity at the 49th annual convention was the banquet on Wednesday evening in the American Room at the Traymore Hotel. This is a sectional view of the banquet room.



2 WAYS

TO APPROACH A COLOR PROBLEM

PULL THE ANSWER OUT OF A HAT OR ASK DRAKENFELD TO HELP

YOU won't find the solution in a hat. It's a tough job even when you knuckle down to a porcelain enamel color problem in your plant because you just have to steal time from other important production operations. Magic won't work. But we feel certain that Drakenfeld know-how can help you appreciably.

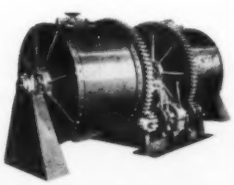
Over the years, Drakenfeld has worked closely with many porcelain enamel manufacturers. We believe that our technologists can be of real service to you in the formulation of new colors and in the matching of old. When we formulate a porcelain enamel color that satisfies your requirements, you can rest assured that each reorder will be handled with the same careful attention to details. That's one of the reasons why you can rely on Drakenfeld to help you work out colors that "fit" your frits for porcelain enameled utensils and appliances for home, institutional and professional use, for signs, for porcelain enamel required for architectural and industrial purposes.

Let us demonstrate how we can help you achieve greater production, fewer rejects, and better, more profitable products. Give us your requirements. Write Drakenfeld today.

DEPENDABLE SERVICE ON: Oxide Colors . . . Screening Paste . . . Graining Colors . . . Squeegee Oils and Mediums . . . Rotospray Sifters . . . Steveco Grinding Mills . . . Porcelain Grinding Balls . . . Porcelain Mill Linings.

5 SAVINGS WITH STEVECO MILLS

Time
Labor
Horsepower
Floor Space
Initial Costs



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Enamel division program report

A. C. S. forty-ninth annual meeting

photographs are of new enamel division officers

with comprehensive authors' resumés of division papers

J. J. Canfield, chairman

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F. R. Porter, trustee

The Enamel Division presented a full program of technical papers at the 49th Annual Meeting. Responsibility for the program was in the hands of the committee headed by J. J. Canfield, American Rolling Mill Co.

Division officers were: F. R. Porter, Inland Steel Co., trustee; Clark Hutchison, Ingram-Richardson Manufacturing Co. of Indiana, chairman; and D. G. Moore, National Bureau of Standards, secretary.

Presiding chairmen for the various sessions, which were broken into half-day sessions, were: Karl Kautz, Climax Molybdenum; Waldo Higgins, A. O. Smith Corp.; G. H. Spencer-Strong, Pemco Corp.; Dwight Bennett, University of Illinois; and Clark Hutchison.

For the benefit of *finish* readers, through the cooperation of the American Ceramic Society and the authors, comprehensive authors' summaries are presented in this section.

The new committee heads include: H. D. Carter, The Harshaw Chemical Co., division nominations; D. G. Moore, papers and programs; B. J. Sweo, Ferro Enamel Corp., membership; E. E. Bryant, Ferro Enamel Corp., research; G. H. McIntyre, Ferro Enamel Corp., classifications and nomenclature; W. H. Pfeiffer, Frigidaire Division, General Motors Corp., rules; and R. L. Fellows, Chicago Vitreous Enamel Product Co., bibliography.

D. G. Moore, vice chairman

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F. A. Petersen, secretary

The mechanism of fracture in porcelain enamels

By Paul L. Smith

This paper discusses the work on enamel fracture carried on by the PEI research associate at the National Bureau of Standards during the period 1937-1941. The point of view adopted in this work was that a study of the cracks in enamels, particularly the origin and method of propagation, was necessary before any clear picture could be obtained of how the fracture occurred, how it should be measured, and what properties of the enamel were most important.

On this basis it was found that enamel failures, excluding impact, could be divided in two classes: (a) those of external origin where the fracture started at the outer surface of the cover coat, and (b) those of internal origin where the fracture

started within the enamel usually within the ground coat. The mechanism of the failure for these two cases is discussed briefly with diagrams and photographs of examples. For the "external" failures, a satisfactory test was developed (PEI Torsion test) and the effect of most of the variables can be predicted from elementary considerations. Failures of internal origin are not so well understood. No quantitative data are available because no satisfactory method of measuring this type has been developed.

Impact fractures are too complicated to fit the above classification since, in general, they have two separate origins — one internal and one external.

Omitting the finer details we find the impact occurs in four stages: (1) An initial failure within the ground coat below the point of impact, (2) A cracking of the cover coat around the point of impact, (3) Propagation of the crack through the ground coat, and, (4) Final cracking of the enamel from the specimen in several pieces.

The initial failure in the ground coat has not been reported before and is not easily observed, so the evidence for its existence and the explanation are discussed.

The propagation of the crack through the ground coat and the final flaking off (stages 3 and 4) appear to be more important than the initial failure (1 and 2). In particular the cracking of the cover coat (stage 2) which has received some attention because of its similarity to "cone flaws" in glass is shown to be relatively unimportant. The evidence for this conclusion is found from the effect of cover coat expansivity, enamel thickness, and the humidity, on impact resistance.

It is suggested that the ground coat plays its most important part during stage 3, and that the effect observed by Fellows and Wheeler is more likely due to changing bubble structure rather than to thermal stress.

It is shown that for purposes of discussing the fracture we have to think in terms of forces exerted on the specimen and the deflections produced rather than the energy of the impacting object. Although these are very difficult to measure accurately, they are useful in providing qualitative explanations of what occurs during impact. Relating the four stages of the impact to force and deflection we find that 1 and 2 are caused by local stresses at the point of impact and therefore depend chiefly on the force developed; stage 3 depends on both force and deflection, and stage 4 depends almost entirely on the deflection produced in the specimen. The role of deflection in producing stages 3 and 4 is shown by experiments under different conditions of backing of the specimen and from a consideration of the area of enamel removed in relation to the energy of the blow. The increase of impact resistance with increasing metal thickness observed by Petersen and Andrews is ascribed to decreased deflection for a given blow.

Present day tests use the energy of the impacting body for the blow which causes failure as the impact resistance. This is a convenient way of obtaining a single number to evaluate different specimens but can be misleading. The difficulty is that the same energy can be produced in two ways, for example by a small mass at high velocity or a large mass at low velocity.

The two types of blow will produce different forces and deflections even though the energy is the same. The essential point is whether the damaged area is bent to a simple shape during impact or whether a large number of small ripples are produced. These small ripples tend to dissipate the energy of the blow in ways which do not damage the specimen. In general the higher the velocity the more ripples and the less damaging the blow. Ordinarily the velocities in two tests will not vary enough to be important but with tests using a small mass this point must be considered.

It should be noted that the picture of enamel failures described here was based on work on enamel thicknesses of the order of 10-30 mils and on radii of ½" or larger. Under other conditions, particularly with the very thin coatings used in some modern applications, the type of failure may change so that the mechanism described here is no longer applicable. Even if this is true, however, the method of attack suggested, that is, a study of whatever cracks do form and their relation to the forces and deflections involved, will still be useful in interpreting the results of impact measurements.

The effect of chemical preoxidation of steel in promoting the adherence of cover coat enamels

By H. S. SAUNDERS

The adherence of enamels to sheet iron or steel has long been a problem to the enameler. A survey of the enamel literature shows that a considerable amount of work has been done, and several theories advanced as to the cause or causes. No one theory has yet gained complete acceptance. One fact now generally accepted is that any sheet iron to which an enamel adheres well has, at the glass-iron interface, a layer of iron oxide. It was thought that rather than obtaining the oxide layer from the use of the oxidizing agent, cobalt oxide, suspended in a glassy matrix, or by preheating the steel in a furnace, that treatment of the steel with strongly oxidizing solutions might produce a surface to which cover coat enamels would adhere satisfactorily.

In this work six commercial cover coat enamels using both regular and acid resistant antimony, zirconium, titanium and clear frits were milled to a fineness of 1 to 3 grams in the usual manner, and applied directly to cleaned, chemically preoxidized regular 20 gauge enameling iron, and a special 20 gauge enameling iron,

and fired over a range of temperatures.

The cleaning and pickling practice followed was the normal commercial process using a boiling commercial cleaner, followed with a rinse. Substituted in place of the usual acid treatment were the various oxidizing solutions. The sample plates were then rinsed and given a soda ash and sodium cyanide neutralizing bath.

Another series of plates were given a nickel dip prior to neutralization.

The oxidizing agents used were dilute nitric acid, dilute chromic acid and potassium permanganate, potassium dichromate, and ammonium persulphate, manganese dioxide and sodium nitrate in dilute sulphuric and dilute hydrochloric acids.

The enamels were applied to these plates at a dry weight of 40 grams per square foot, titanium enamels at 20 grams per square foot, and fired at temperatures varying from 1460° F. to 1580° F. so that fusion of the enamels was obtained at each temperature.

All of the sample plates were tested for adherence, and comparisons were made with a regular commercial ground coat applied to regularly treated steel.

From the experimental data compiled, it is concluded that cover coat enamels or any enamel glass can be made to adhere to enameling iron by chemical preoxidation of the metal surface, without the use of the normal adherence promoting oxides in the glass.

In some instances, the use of a nickel flash in conjunction with preoxidation promotes adherence superior to that produced by any other method.

The special steel used produces a much more satisfactory surface or finish when enameled than regular enameling steel, and offers a possibility of one coat enameling practice, with excellent adherence.

Suppression of radiations at high temperatures by means of ceramic coatings

By D. G. BENNETT

Background: Visible glow radiations from hot exhaust stacks and collector rings of aircraft offered a means for enemy detection in various theaters of war. Sensitive instruments could detect approaching airplanes at greater distances by their reaction to the longer, invisible (infrared) radiations given off by exhaust systems.

Significance: This paper describes the successful development of ceramic coatings able to suppress most of the visible and invisible radiations from heated metal. As often happens, the original objectives were by no means the last. The protection afforded to the metal of aircraft power systems by selected ceramic coatings interposed between the metal and the gases of combustion was recognized.

The work was carried on as a special project in a broad program of research on ceramic coatings to protect heated metal and ceramic bodies for use in high temperature zones of aircraft power systems. The program is sponsored by the Power Plant Laboratory of the Air Materiel Command, Wright Field, Dayton, Ohio, and is being carried on in the Department of Ceramic Engineering, University of Illinois.

Method of approach: As a reference standard (curve) it was decided to measure and plot the intensity of radiations from well oxidized stainless steel over a temperature range of 800-1600° F. Figure 1 shows the assembled equipment appropriately described. Radiations were restricted to either visible red or infrared bands by the use of proper filters.

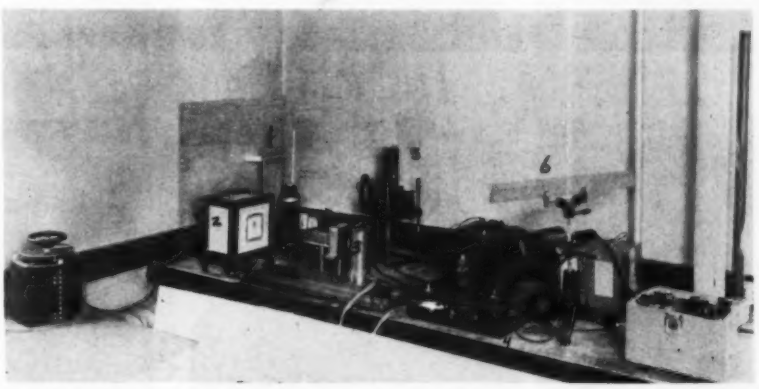

FIGURE 1 — *Equipment for measuring relative emissivity includes (1) variac transformer, (2) specimen heating furnace, (3) copper shielded photocell, (4) resistance coupled amplifier, (5) galvanometer, and (6) Cm scale.*

Of many ceramic materials, nineteen which might be used as the principal components in ceramic coatings were selected for complete investigation. Each material was uniformly wet milled with 20 per cent by weight of a refractory but high expansion bonding glass, and applied by dipping to steel test plates which carried a previously applied uniform (4 mils) application of base coat. The "top coatings" for radiation suppression were held at a fired thickness of 14 mils ± 0.5 mil. They were fired on for 10 minutes at 1750° F.

All such coated plates were measured for intensity of emitted radiation in the selected wave band at successive 50° F. temperature increments. The caesium photocell (see Figure 1) was exposed to the radiations with the resulting electrical energy being passed through a sensitive reflecting galvonometer. The control curve for oxidized stainless steel was obtained in exactly the same way.

Results: The relative emissivities in the infrared for a representative list of ceramic materials are shown in Figure 2. The control curve labeled S.S. 321 represents the increase

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→ *from Page 31*

in emissivity with respect to temperature of oxidized stainless steel type 321. Similar curves were obtained in the visible red band over the same temperature range of 1100-1600° F. The per cent emissivity of any one of the ceramic materials with respect to stainless steel at any given temperature may be found by taking the ratio of the ordinates x 100, at the temperature selected.

In Figure 3 the per cent emissivity for each of the ceramic materials with respect to stainless steel is plotted against increase in temperature. A slight but definite upward slope for each curve will be noted. This is in keeping with radiation laws which state that non-black bodies (gray bodies) increase in emissivity more rapidly than do black bodies as the temperature is increased. Stainless steel, as enclosed in the furnace, is closer to being a black body than any of the ceramic materials studied.

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Effect of firing treatment of ground coats on quality of dry process enamels for cast iron

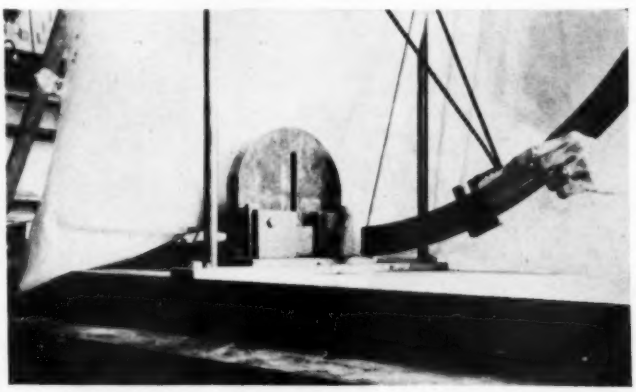
By R. R. Danielson and J. H. Koenig

The effect of varying firing treatment of ground coats on the quality of adherence and the tendency to blister of dry process enamels for cast iron was studied. Five ground coats composed of one and two frits and with various clay and flint additions at the mill were used. The adherence of the enamels was measured by means of a pendulum type impact tester, with the blow applied to the backs of the specimens.

The impact required for failure of the enamels ranged from about 0.60 to 2.33 foot-pounds. The latter was the maximum blow obtainable with the apparatus, and several specimens required repeated blows of this force. This method of testing apparently gives a satisfactory measure of the ground coat and cover coat adherence.

After preliminary trials, a standard firing procedure was adopted for the ground coats as follows: 14, 18 and 22 minutes at 1600° F., 10, 14 and 18 minutes at 1685° F. A standard lead-bearing sodium antimonate cover enamel was applied to all specimens for the impact test and fired at 1600-1620° F.

There is a critical temperature, about 1685° F., beyond which ordinary commercial ground coats should not be heated for best adherence and freedom from blistering. This temperature is below the usual furnace operating temperature, and the ware should be put through the furnace at a rate which avoids heating the castings above the critical temperature. Data were obtained which indicates that the castings, during firing of the ground coats under laboratory conditions, reach equilibrium with the furnace temperature in 6 to 7 minutes and then exceed it by 25° to 35° F. One suggested explanation for this differential is the thermal reactions within the iron, such as oxidation of the silicon.



Adherence was measured by this pendulum type impact testing apparatus.

The use of ground coats with appreciable amounts of raw material and a blend of fusible and refractory frits appear to improve the firing range. Further work on the effect of varying frit compositions and mill additions is planned, as a satisfactory procedure for studying the firing range and adherence of ground coats has now been provided.

This investigation is being conducted under the sponsorship of the Research Advisory Committee on Enamels of the New Jersey Ceramic Association at the School of Ceramics, Rutgers University. Several of the prominent manufacturers of cast iron sanitary ware are cooperating in the work.

Determination of compression present in porcelain enamel on sheet iron

By E. E. Bryant and M. G. Ammon

A method for determining comparative compressive stress produced in porcelain enamel on sheet iron is described. The method consists of preparation of laboratory samples under carefully selected and controlled conditions and measurement of the warpage produced in the sample due to application of enamel on one side.

Data obtained by this method is compared with expansion curves. Several methods of analyzing the curves fail to produce correlation between expansion as determined on frit samples and compression in the porcelain enamel as indicated by the warp of sample plates.

The conditions for production of samples for the warpage test include selection of steel for thickness and method of cutting from the original sheet. The sample plates are 4 x 12 inches and are cut with 12 inch di-

mension from the length of the original sheet. Thickness of steel is controlled to plus or minus 1/1,000 inch.

Application of enamel on the 4 x 12 samples is held to plus or minus ½ gram per side. It was found necessary to prevent buckling and distortion of samples due to unequal heating from the edge to the center of the piece. This was accomplished by brushing out an area one inch in width and for the full length of the sample for each coat that was applied over the ground coat. This overcame large discrepancies between duplicate samples.

A dial indicator was used to measure warpage or bow in the sheets when supported over a ten inch span. Results were reported in inches of warpage. Curves were plotted for warpage against weight of application of cover coat.

A comparison of the warpage curves with expansion curves of the same enamels show wide discrepancies. A complete study of the expansion curves indicates that it is impossible to correlate the expansion of the glass with the compression as indicated by the warpage test. Attempts to produce cooling curves indicate one of the reasons for the discrepancies.

It is concluded that expansion curves on frit samples are not a satisfactory means of evaluating compressive stress in the porcelain enamel coating on sheet iron.

Measurement of enamel slip consistency by means of the Brookfield viscosimeter

By E. M. Oliver

An instrument commonly employed to measure the viscosity of truly viscous liquids was tested to determine its applicability for evaluating consistencies of enamel slips which are solid suspensions in a water medium. This instrument, the Brookfield Synchro-Lectric viscosimeter, operates on the principle that a measurable drag is imposed when its rotating spindle is immersed in a material under observation.

The measurements of the drag imposed, or apparent viscosity, were compared with the "slump" and "pick-up" tests within wide limits of specific gravity differences and variations in set resulting from electrolyte additions. The values obtained with the viscosimeter are designated "apparent viscosity," because enamel slips are solid suspensions rather than truly viscous liquids, and are therefore subject to thixotropy. It is essential that the time element be considered in making tests of this nature.

In every instance where a change is indicated by the reference tests, a corresponding change is evidenced in the viscosimeter test. Only data which pertain to a typical commercial zirconium opacified sheet steel cover enamel are presented, since they embrace such a large span of consistencies. However, some exploratory studies have been made on other enamels, such as a sheet steel ground coat and a titanium opacified cover coat, with highly satisfactory results. Sufficient data were obtained to indicate the viscosimeter's successful application to these enamels.

If handled with reasonable care, and by observing certain precautions, the Brookfield Synchro-Lectric or similar instrument should afford the following advantages in measuring or controlling enamel slip consistency: (1) rapid determinations, (2) results translatable into absolute viscosity units, (3) wide ranges, (4) high accuracy and good reproducibility and (5) portability.

The determination and effect of sulfur gases in plant atmospheres

By B. J. Sweo and M. J. Bozsin

The information presented is the result of a study of a severe scumming condition in a plant producing porcelain enamel ware. This plant had experienced some scumming periodically for a number of years, and more recently the condition became so severe that scumming was encountered consistently, seriously handicapping production. Discussion of the problem with plant personnel brought forth a variety of opinions embracing all operations as probable causes of scumming; however, some of the observations appeared significant. Aged ware showed the greatest tendency to scum, whereas freshly sprayed ware seldom scummed. Covering of the ware during the aging period prevented scumming. Removal of the surface layers of the enamel by brushing also prevented scumming. Spraying of the unfired enamel with water was effective in eliminating this defect. A critical analysis of the foregoing observations indicated that scumming, in this case, was associated with a surface condition of the ware which appeared to be related to atmospheric conditions within the shop. In view of published work indicating a close relationship between sulfur gases and scumming, study of the problem was directed toward determining the sources of sulfur compounds and their relation to scumming. The study involved investigation of all raw materials and each processing step in the production of the ware. Quantitative tests were conducted to determine the amounts of sulfur compounds present in the raw materials, the milled enamel and the unfired enamel on the ware. Similar information was obtained relative to the sulfur content of the fuel, the furnace muffle atmosphere, the dryer atmosphere, the plant atmosphere and the combustion gases.

Analysis of milled enamel and unfired enamel removed from ware showed a higher sulfur compound content than would be anticipated from the analysis of the raw materials. Unfired enamel showed a variation in sulfur compound content as a function of the aging time; namely, it increased with increasing aging time. Analysis of miscellane-

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ous materials, including shop dust from several sources, water from the dryer humidifier pans and enamel mill liquor, showed sulfur compounds to be present in all cases. For example, dust from the air compressor filter was found to contain 6.55 per cent sulfate calculated as sodium sulfate.

The furnace combustion gases, the furnace muffle atmosphere, the dryer atmosphere and the plant atmosphere were found to contain sulfur gases to the extent of 5, 12, 4 and 6 parts per million, respectively, calculated as sulfur trioxide. It is significant and apparently anamolous that the furnace muffle shows a higher concentration of sulfur gases than the combustion gases which are the source of the sulfur. Liberation, during firing, of sulfur gases previously absorbed by the ware would account for the higher concentration in the muffle atmosphere.

To demonstrate the absorption of sulfur gases, pans of distilled water and enamel mill liquor were exposed to the plant atmosphere for varying periods of time and analyzed for sulfur compounds. It was found that the degree of absorption was directly proportional to the time of exposure, and that enamel mill liquor absorbed sulfur gases at a much greater rate.

Orsat analysis of the furnace stack gases showed the furnace to be burning with a high excess of air. Pressure readings in the muffle were positive, indicating a leak in the muffle wall. Adjustment of the combustion to approach optimum conditions reduced the muffle pressure, and the scumming condition was reduced to such a point that the ware was unaffected unless exposed to the shop atmosphere for extended periods of time.

Analysis of the fuel gas showed to contain 1.2 grains of sulfur per 100 cubic feet of gas. Compared with a good grade of fuel oil, on an equivalent B.t.u. basis, this fuel is considered excellent from the standpoint of sulfur content.

The cessation of scumming with the adjustment of the furnace combustion conditions would indicate a change in the muffle atmosphere to a condition which produced no scum. However, in view of the fact that freshly sprayed ware did not scum whereas the normally processed ware scummed, it is indicated that factors other than muffle atmosphere must be considered. Ware which had been exposed to shop atmosphere for some time did not scum when fired in a laboratory furnace free of sulfur gases, but scummed badly when fired in the plant furnace. It appears, therefore, that a combination of conditions acted to produce scumming; namely, the absorption of sulfur compounds by the ware and the firing of the ware in an atmosphere contaminated with deletereous gases, including those of sulfur. In view of the positive pressure in the furnace muffle which would insure passage of the gases to the shop atmosphere where they are available for the absorption by the ware, these two conditions are closely related. The highest concentration of sulfur gases being in the muffle indicates that sulfur gases previously absorbed by the ware are liberated on firing. These gases would be returned to the shop atmosphere for reabsorption by the ware.

It may be concluded that scumming in this particular case was due to a combination of conditions including (1) absorption of sulfur gases by the unfired ware, and (2) firing such ware in a furnace atmosphere containing gases generally considered to be deletereous, including those of sulfur.

The effect of variations in color stains on the colors produced in porcelain enamels

By RALPH L. COOK AND ROBERT W. PELZ

A representative series of colors—blue, brown, green, red and yellow—was selected for the investigation. The base stains were as shown in the accompanying table, and, except for the reds, variations of 15% in each of the constituents were made, giving a total of five stain compositions for each color. The reds were varied only 10%.

Base Stains

Blue		Brown		Green		Red		Yellow	
Co_3O_4	43.6	$M_2Cr_2O_7$	24.0	$CaCO_3$	22	CdO	8	Al_2O_3	8
Al_2O_3	54.9	Fe_2O_3	18.5	CaF_2	17	CdS	70	Sb_2O_3	32
ZnO	0	Al_2O_3	47.5	Cr_2O_3	39	Se	20	Pb_3O_4	44
NaCl	1.5			SiO_2	22	$CaCO_3$	2	SnO_2	16

The blues, browns and greens were calcined at 2300° F. The yellows were calcined at 2150° F. The reds were calcined at 1020° F. After calcination, all the stains were ground to pass 325 m. and washed.

A clear frit free of lead and zinc was used with an appropriate amount of each stain to produce a sufficiently intense color. The colored enamels were sprayed over ground coated panels in two coats to a final dried weight of 65 gms/ft, and fired at 1500° F. for 3 minutes.

Spectrophotometric reflectance curves were plotted from the finished panels with a recording spectrophotometer. The resulting curves were analyzed on an integrating calculator, using C illuminant as the comparison standard. The resulting tristimulus values were then converted into trichromatic coefficients, and these factors were plotted on a chromaticity diagram to determine the dominant wavelength and purity of each enamel.

As the compositions of the blue stains varied from 100% cobalt aluminate to 50% cobalt aluminate and 50% zinc aluminate, the brightness, purity, and dominant wavelength of the blue increased. As the alumina content was increased, the brightness increased slightly and the dominant wavelength decreased 9%.

In the group of brown enamels produced, the brightness varied only

slightly, the dominant wavelength shifted from 5830A° to 6010A°, and the purity varied from 13% to 35%.

The green panels showed very little change in brightness and dominant wavelength, but the purity of the colors varied from 14% to 29%.

The yellow stains caused little change in dominant wavelength, but produced changes in brightness from 17% to 28% and in purity from 39% to 62%. The yellows with high lead content produced the purest colors.

Although the reds were varied only 10% in any direction from the base stain, these changes produced a greater variety in shades than any of the other stains. The brightness changed very little, but the dominant wavelength and purity varied considerably.

Since the cadmium-sulfo-selenide reds are known to be quite sensitive to temperature variations, the effect of change of calcination temperatures was studied. The calcination temperatures were varied. Three calcination temperatures were selected — 450° C., 550° C., and 650° C. From the data obtained in this study it was observed that, in general, a change in calcination temperature had little effect on the brightness of the color, but the dominant wavelength and purity were changed. As the selenium content increased, the change increased.

Refractory ceramic base coats for metal

By W. J. PLANKENHORN

The University of Illinois Engineering Experiment Station has been, since June, 1943, and is presently, engaged in a research program sponsored by the Power Plant Laboratory of the Army Air Forces, Air Materiel Command. The work is being carried on in the Department of Ceramic Engineering. The program includes the development of ceramic coatings for the protection of ingot iron, low carbon steel and stainless alloys from oxidation and deterioration at elevated temperatures.

Commercial enamel frits were used initially with relatively large percentages of refractory materials being added at the mill. Magnesium oxide, beryllia, chromic oxide, diaspore and molybdenum trioxide, were tested as refractory mill additions. The mineral diaspore containing 60 to 70% aluminum oxide was found to best combine the properties of workability and sustained resistance to high temperature when added as a refractory mill addition. There proved to be an optimum amount of diaspore that could be added to coatings developed from a specific frit. The maximum amount of diaspore that could be used was such that it would still permit the coating to fuse and seal off the metal before slag spots formed. Molybdenum trioxide was found to increase the refractoriness and to reduce the copperheading tendency prevalent with refractory coatings.

These coatings were effective in protecting ingot iron and low carbon steel from oxidation for considerable periods of time at temperatures up to 1500° F. Figure 1 shows a low carbon steel cylinder which was heated

FIGURE 1 — *The effectiveness of refractory ceramic coatings in protecting metal from oxidation during extended heat tests is pictured.*

for 50 hours at 1500° F. The cylinder had been coated on the inside only with a refractory ceramic coating. As can be seen from the picture, deterioration progressed from the outside in, the inner surface being protected.

Special refractory frit glasses were developed to produce coatings with greater protective value. Starting with known compositions, studies were made of the effect of systematic variations of the constituents. New coatings were formulated based on the results of these investigations and on accumulated information regarding the properties of various oxides when incorporated into glasses.

Zirconia, ceria, beryllia, lithia, titania, molybdenum trioxide, and alumina were included in the list of raw materials investigated. Considerable quantities of zirconia and ceria were used in refractory frit glasses with promising results.

Several of the coatings developed for iron were applicable to stainless steel. Other refractory coatings were developed for specific alloys.

The base metal, carbon content, and the material used as a stabilizer in stainless steels were found to have a greater effect upon the enameling properties than the coefficient of expansion. Figure 2 reproduces the expansion curve for 18-8 stainless steel type 316 and two frits which differ widely in expansion but produce workable coatings for this metal.

Raw base coats, containing up to 100% nepheline syenite and others containing large percentages of feldspar were developed and tested. Eutectic mixtures of three and four component systems were fritted and milled into coatings. Coatings were produced which continued to protect alloy metals after 50 hours of heating at 2000° F.

The importance of cobalt, nickel and manganese oxides, as adherence promoters, was studied. Initial adherence was usually better when these oxides were present in the frit, but the loss of adherence was more rapid during extended heating at elevated

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The name VITRO assures all this and more. It stands for Quality, Experience and Service—based on over forty years of service as color specialists to the ceramic industry. VITRO is a name you can depend upon.

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temperatures. The most favored refractory coatings developed to date do not contain nickel, cobalt or manganese.

There were strong indications that the chemical composition of the oxide formed during firing and subsequent periods of heating, the amount of oxide formed, and the ability of the coating to absorb this oxide determined the degree of adherence developed between a ceramic coating and any given metal.

Metal preparation proved to be a significant factor in the successful coating of stainless steel and special alloy metals. Sandblasting was the one method of metal preparation that could be universally used. Better adherence was obtained when the metal had been scaled and sandblasted prior to coating than with any other method of preparation. This was true of stainless steels, low carbon steel and ingot iron.

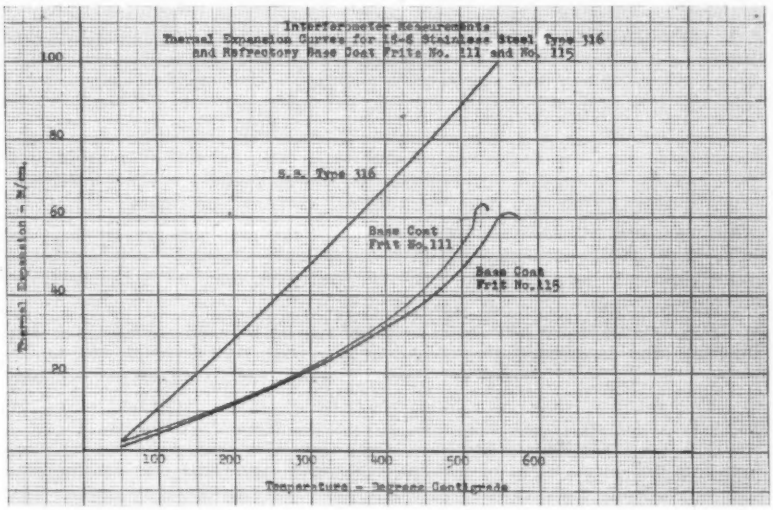


FIGURE 2 — *Reproduction of the expansion curve for 18-8 stainless steel type 316 and for base coat frits No. 111 and No. 115.*

Button flow tests were used to compare the refractoriness of the frits and coatings developed. The interferometer was used in obtaining the coefficients of expansion of frit glasses, metals and coatings. Firing spreads of the various coatings were made. Equipment producing a constant deformation in a coated sample was used to determine and compare adherence. Resistance to thermal shock was determined by coating the inside area of metal tubes 2½" in diameter and subjecting them to repeated heating and cooling cycles on a gasoline or gas torch test stand. Sample plates were coated and subjected to extended heat tests at various temperatures to determine the protective qualities of the coatings. Service or operational tests were used to obtain a final evaluation of refractory ceramic coatings. Buckets for turbo-supercharger turbine wheels were coated and tested. Wheels with coated buckets invariably operated at greater speeds for longer periods of time. Combustion chamber liners, tail cones, tail pipes, compressor stators and rotor buckets for jet plane engines were coated and tested. The results were encouraging.

The coatings developed in this program have produced some favorable results. They are a step in the direction of applying ceramic materials to meet the high temperature problems of the aircraft industry. Ceramics can play an important part in the advancement of aeronautics. Projects of the type described are playing a significant part in developing ceramic coatings to meet the demands of the Army Air Forces in supplying factual data to advance ceramic technology.

The effect of composition on the properties of titanium enamels

By A. L. FRIEDBERG, F. A. PETERSEN AND A. I. ANDREWS

The development of a super-opaque acid-resistant titanium enamel was described. Several components of the batch were varied systematically, and the properties such as reflectance, color, flow, gloss, and acid resistance were determined.

The development of opacity in enamels of this type depended on the solution of all material in smelting to form a clear glass frit and the recrystallization of the opacifying agent during the firing process.

The effect of studied changes in composition on a selected base enamel showed that:

1. The Na_2O-K_2O ratio should be high in Na_2O percentage for best overall results in flow, color, and reflectance. High percentage of K_2O decreased flow and reflectance and shifted the color to a bluish white.

2. The Na_2O-B_2O_3 ratio is critical. For best overall results in flow, color, and reflectance, the ratio of Na_2O to B_2O_3 should be 1 to 2. Enamels with ratios high in B_2O_3 showed a tendency to a bluish white, while enamels with ratios low in B_2O_3 showed a tendency toward a cream color.

3. The best combination of ZnO, MgO, and CaO was found to be 1:2:1. The addition of MgO to the enamel increased reflectance, but large additions of MgO made the enamel too viscous. High percentages of ZnO and MgO produced a tendency to bluish white enamels.

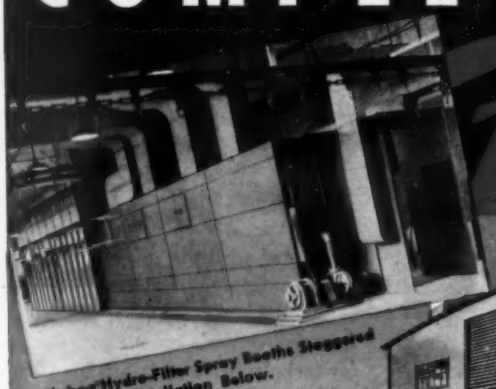
4. Increase of titania content increased reflectance to a miximum after which additional increase of titania causesd excessive crystallization with an accompanying loss in gloss, reflectance, and fluidity.

Smelting tests indicated that oversmelting as evidenced by the yellow to brown coloring of frit lowers re-

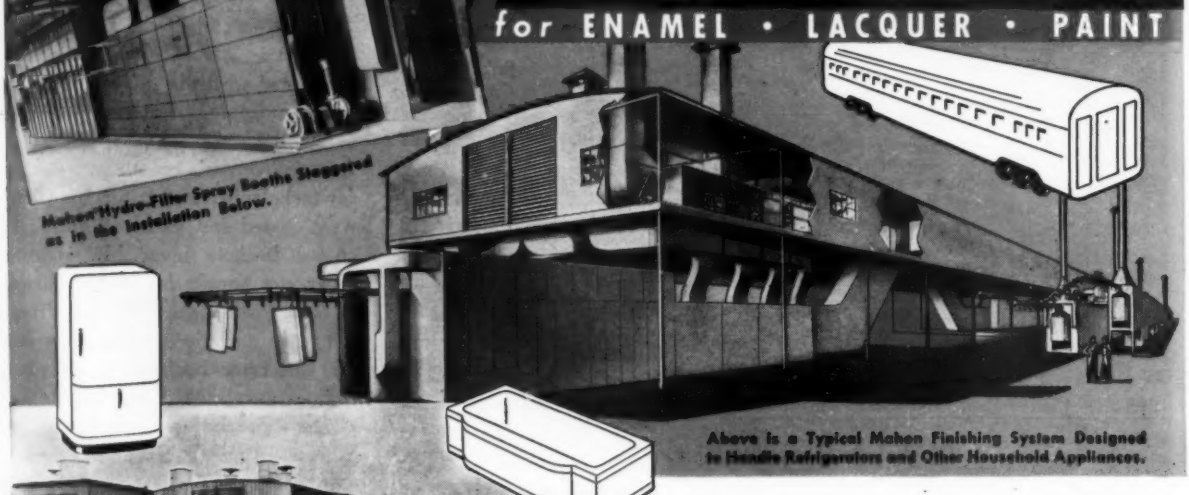
to Page 52 →

COMPLETE *Finishing* SYSTEMS

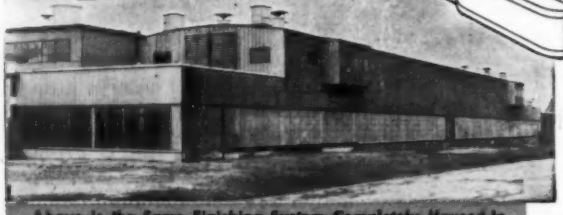
for ENAMEL • LACQUER • PAINT



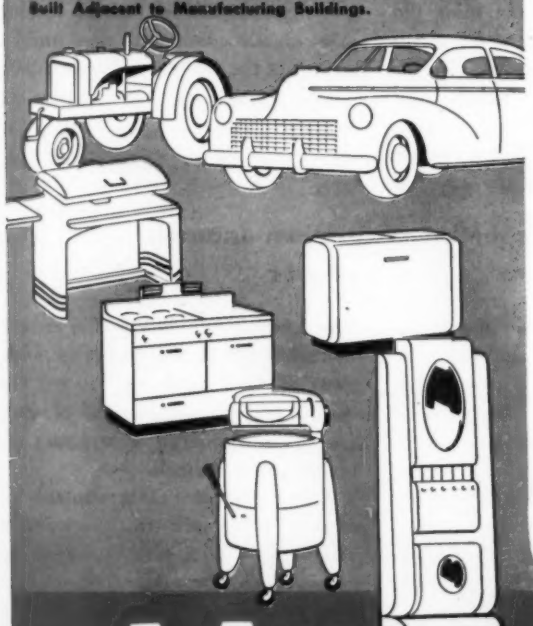
Mahon Hydro-Filter Spray Booths Staggered as in the Installation Below.



Above is a Typical Mahon Finishing System Designed to Handle Refrigerators and Other Household Appliances.



Above is the Same Finishing System Completely Housed-In by Mahon. This Installation, Due to Space Restrictions, was Built Adjacent to Manufacturing Buildings.



. . . Experience Gained In Many Industries Assures Better Planning, Better Engineering

In the planning and engineering of modern Finishing Systems to meet the requirements of present-day production methods, there is no substitute for experience. That is why so many manufacturers in every industry all over the world turn to Mahon for the ultimate in modern finishing equipment . . . they know that for over twenty-five years the Mahon organization has pioneered this highly specialized field. Constant research, development, and close contact with production experts in every industry where finishing constitutes a major production operation, have endowed Mahon engineers with a wealth of technical knowledge and practical know-how not available to you elsewhere. See Mahon Insert in Sweet's Mechanical Industries File, or if you are contemplating new equipment in the near future, a Mahon engineer will gladly consult with you on your requirements.

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MAHON

NEWS

The Du Pont Company, Wilmington, Delaware, has announced the appointment of Edgar A. Thronson as assistant director of the technical division of the electrochemicals department.

Thronson joined Du Pont in 1929 soon after his graduation from the University of Wisconsin.

Apex re-elects directors and officers

Directors and officers of the Apex Electrical Mfg. Co. were re-elected at the annual stockholders' and directors' meeting held April 21 in Cleveland, Ohio, according to a company report which also announced the election of Donald W. Randolph to the newly created position of vice president and director of research and engineering.

The company completed development of two automatic cycle-type washers, each distinctly different in principle, according to C. G. Frantz, president. He said that because of the very large program for the manufacture of its present line of products, production of automatic washers will be secured partially through outside contractors, with Apex absorbing into its own plants such operations as readily fit into available facilities.

Pennsalt names assistant vice president

William P. Drake, manager of sales of the special chemicals division of the Pennsylvania Salt Manufacturing Co., has been appointed assistant vice president, according to George B. Beitzel, vice president in charge of sales.

Drake joined Pennsalt in 1934. A native of Bath, Maine, he attended Deerfield Academy and Bowdoin College.

New president at Despatch Oven

George M. Lund was elected by the board of directors to head the Despatch Oven Company, according to A. E. Grapp, chairman of the board.

Lund took over the position as president of Despatch after many years with the company as comptroller, vice president and assistant to the president.

Mr. Lund has the support of C. P. Doherty, executive vice president and general manager, a 28-year employee of the company.

Other officers and directors appointed include G. L. Schuster, vice president-treasurer and chief engineer; Fred Larson, vice president-secretary and chief electrical engineer; Ida S. Grapp, director, and John W. Watson, vice president in charge of the Chicago branch.

Founder of the company in 1902, A. E. Grapp has always been active in its direction, and plans to continue as active board chairman.

The recent changes in the top personnel of the company followed the sudden death of H. L. Grapp, who had become the president in 1946. The deceased head of the company, who died unexpectedly March 22, while on a vacation in California, was the son of A. E. Grapp.

Cleghon retires

Claude C. Cleghon, superintendent of the porcelain department of Clyde Porcelain Steel Corp., Clyde, Ohio, since November 18, 1935, resigned May 1. He plans to retire to his original home in Florida after 20 years spent in the porcelain finishing field.

Cleghon first started with the Samuel Stamping & Enamel Co., Chattanooga, Tenn., April 6, 1927. In 1931 he joined the Mullins Mfg. Co., Salem, Ohio, remaining there until going to CPS.

In submitting his resignation to R. R. Trubey, executive vice president, Cleghon said that he wished to retire for some time, but had remained because of loyalty to Trubey.

In announcing the resignation, Trubey said that Ernest Higley, assistant superintendent, had been elevated to superintendent, while Harry Neely, a continuous furnace room supervisor, would be assistant superintendent. Higley has been with CPS since 1935, starting as a night foreman.

D. L. Brandon has been appointed assistant purchasing agent of the Refrigerator Division of Philco Corporation, according to an announcement by William MacMurtrie, general purchasing agent.

Plant expansion at American Potash

The growing demand for borax, soda ash, potash, salt cake and other

chemicals, due to industrial expansion, particularly in the West, resulted in the American Potash & Chemical Corporation, Trona, Calif., awarding a contract this year for construction of a new $3,800,000 plant.

Present plans indicate that the new plant will increase the output of soda ash approximately 70 per cent, and raise borax production about 30 per cent.

Richard Turk heads Pemco

Richard H. Turk, executive vice president for many years, was elected president of Pemco Corporation at the annual meeting of the board of directors held in Baltimore, April 25. He succeeds Karl Turk who continues as chairman of the board.

Other officers elected were: Herbert Turk, executive vice president; W. Russell Greer, vice president; H. G. Wolfram, vice president; George H. Spencer-Strong, vice president; Karl Turk, Jr., treasurer; John R. Reuling, comptroller and assistant treasurer, and Benjamin F. Deford, Jr., secretary.

Stove men meet in Cincinnati

The Mid-Year Convention of the Institute of Cooking and Heating Appliance Manufacturers will be held at the Netherlands Plaza in Cincinnati, Ohio, June 2, 3 and 4. Albert M. Kahn of the Estate Heatrola Division, Noma Electric Corporation, will serve as the convention's chairman.

Northern Ohio Section of ACS to meet June 5

The next scheduled meeting of the Northern Ohio Section of the American Ceramic Society will be held June 5 at the Cleveland Engineering Society preceded by a dinner at 6:30 p.m.

Dr. John M. Gaines, assistant superintendent in charge of new products and processes, the Linde Air Products Company, Tonawanda, New York, will give a talk entitled "Some New Industrial Uses for Oxygen." In conjunction with Doctor Gaines' speech, projected colored slides will be shown to illustrate new applications of the product. A question and answer period will follow the speech.

An industrial sound film, entitled "Story of a Sparkplug," will also be presented.

Reservations for dinner may be made by contacting P. C. Lemmerman, E. I. DuPont de Nemours Co. (Phone Maine 6460), Grasselli Chemical Dept., 1321 Guardian Bldg., Cleveland, Ohio.

Renown Stove appointments

The appointment of Robert J. Wilson as general factory superintendent, and Robert G. Griffin as superintendent of the enamel department, has been announced by B. A. Nagelvoort, president, Renown Stove Company, Owosso, Mich.

Wilson's past experience included 14 years with General Motors, 2 years as factory superintendent with Thorez and Maes, Jackson, Mich., and 3 years as general superintendent at Aeroquip in Jackson. Prior to joining the Renown organization, he operated his own machine shop.

Griffin brought to Renown more than 12 years of experience in porcelain enamel work. He has served as enamel superintendent at the Kalamazoo Stove and Furnace Co., Kalamazoo, Mich., and at the Round Oak Company, Dowagiac, Mich.

Apex sets production record

The Apex Electrical Manufacturing Company, Cleveland, Ohio, set a new production record of 48,885 washers, ironers and vacuum cleaners during March, it has been reported by C. G. Frantz, company president.

The company has scheduled 1947 production at its expanded plants in Cleveland and Sandusky, Ohio, at a rate more than double that of 1941, the company's best pre-war year.

Pig roast at University of Illinois

The annual "Pig Roast" for the Department of Ceramic Engineering, University of Illinois, was held Wednesday night, May 7, at the Urbana-Lincoln hotel. There were about 90 persons present, including members of the staff and graduating seniors.

Roger Westlake, a graduating senior and past president of the Junior Class, served as master of ceremonies, calling on the various graduating seniors who "roasted" the members of the teaching staff.

Waldo Higgins, A. O. Smith Corp., addressed the group. He showed slides of the new Smith plant in Kankakee, Illinois. *(See March, 1947, finish, "The Straight Line Production of Glass Lined Water Heaters.")*

Birdwell to Industrial Enameling

Word comes to *finish* from New Orleans that Ben F. Birdwell, formerly with Porcelain Metals Corporation of Louisville, Kentucky, is now associated with Industrial Enameling, Inc., New Orleans, Louisiana.

This comparatively new porcelain enameling company is in production

on the fabrication and enameling of signs, and has plans for the manufacture of several plumbing specialties in volume for the southern domestic trade and for the export market.

Gordon Johnson gets appointment for new Ferro research fellowship

The establishment on March 28 of a research fellowship, to be known as the Ferro Fellowship in the Division of Ceramics at the Pennsylvania State College, State College, Pennsylvania, has been announced by Dr. G. H. McIntyre, vice president and director of research of the Ferro Enamel Corporation.

Gordon H. Johnson has been appointed by Dr. E. C. Henry, chief of the Division of Ceramics at Penn State, as research fellow on the project. Johnson has been special research assistant in the Departments of Ceramics at the University of Illinois and the Pennsylvania State College. He is a member of Tau Kappa Epsilon, Keramos, Sigma Xi, Pi Mu Epsilon and the American Ceramic Society.

The Ferro Fellowship will be under the direction of Doctor Henry. The studies will be of a fundamental nature furthering basic knowledge in the field of porcelain enamels, and will lead to advanced degrees for the research fellow, the report states.

Perry heads Columbia Steel

J. Lester Perry, assistant to Benjamin F. Fairless, president of United States Steel Corporation of Delaware, has been elected president of Columbia Steel Company, succeeding the late William A. Ross, who died in San Francisco, Calif., April 19.

Perry began his career as a cost clerk, and rose to the presidency of Carnegie-Illinois Steel Corporation. He retired from that post July 31, 1946, to become assistant to Fairless.

Election of M. W. Reed as vice president in charge of engineering of Carnegie-Illinois Steel Corporation was announced by C. R. Cox, president.

George E. Benson, treasurer of The Youngstown Sheet and Tube Company nearly 15 years, retired early in May, according to an announcement at a meeting of the company's directors following the annual meeting of shareholders. John H. Hall, general auditor, was elected treasurer to succeed Benson.

Clark E. Korns, Hammond, Ind., has been appointed supervisor of industrial relations for The Youngstown Sheet and Tube Company's district plants in Chicago.

Korns joined Youngstown in 1940 as assistant to the general superintendent of the strip and tin mills at the company's Indiana Harbor works. Before that he was with Cambria Steel Company and Wheeling steel Corporation.

Housewares and appliance show has 500 exhibits

ENAMELED UTENSIL MFR'S COUNCIL
Kitchenware That Stays Beautiful for Years
PORCELAIN ENAMELEDWARE
Faster Cooking ! Stain Resistant ! Decorative !-
HERE IS THE SCHEDULE OF
FOR THE BALANCE OF 1947
1947

"That's right, Charlie!" . . . . A. Wilson, Lisk-Savory Corp., and E. P. Altemeier, National Enameling and Stamping Company, shown testing the sales talk of EUMC's Charlie Smith for porcelain enameled kitchen utensils in the industry's booth at the recent Philadelphia Housewares Show.

Not a hotel room was available in Philadelphia during the week which ended April and started May, due to the overwhelming demand for hotel space by exhibitors and buyers attending the housewares and major appliance show which convened at Convention Hall.

Five hundred exhibitors showed their appliances and wares in the best light possible for prospective buyers. The spirit of conservatism prevailed among the buyers in attendance.

Prominent among the exhibitors were producers of porcelain enameled cooking utensils. One booth that attracted unusual attention was that

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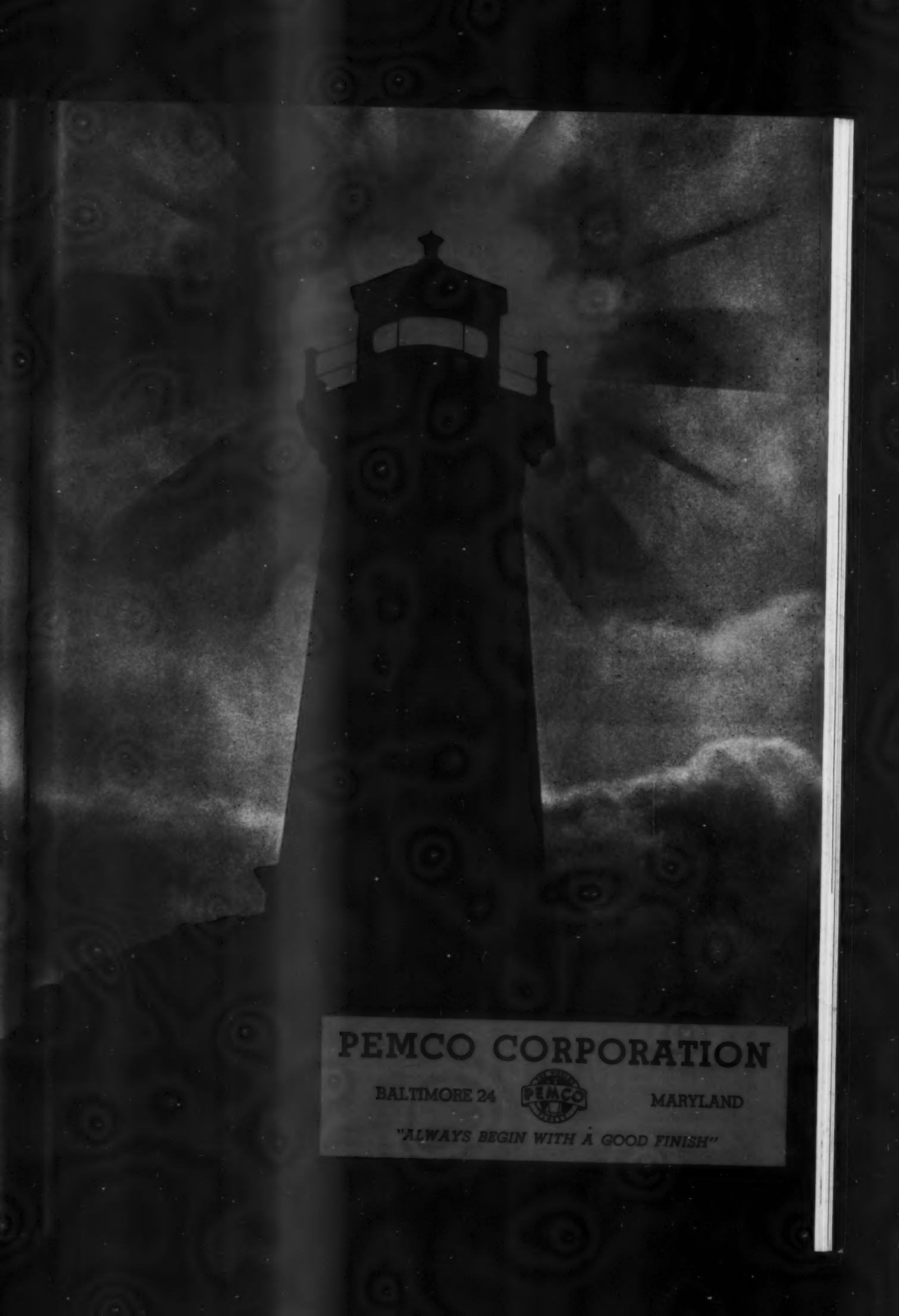
IN THE LIGHT OF EXPERIENCE

A problem arises! Then, guided by the light of experience—a solution—and another step forward to better living. In the light of their experience the porcelain enameling industry has definitely acknowledged the superiority of continuous smelted frit.

In this decision Pemco takes great pride, because when the problem of making a frit of absolute uniformity presented itself it was Pemco who offered the solution—CONTINUOUS SMELTING—and it was Pemco who by calling on experience—ingenuity and research produced the first frit ever made by continuous smelting.

And it is PEMCO TODAY who produces this superlative uniform frit in the ONLY wholly Continuous smelting plant—by means of the ONLY WHOLLY CONTINUOUS SMELTERS in the entire enameling industry. The opportunity of broadening your range of production—increasing your profits may lie within the experience of Pemco. YOU are welcome to draw on this experience, to use it as a guide to the solution of your manufacturing problems and a step toward a mutually satisfactory business association.

** Pemco holds patent rights on the only wholly continuous smelter #2,323,930; 2,262,029; 2,262,070; 2,248,877 2,137,931; 2,137,930*


PEMCO CORPORATION
BALTIMORE 24
PEMCO
MARYLAND
"ALWAYS BEGIN WITH A GOOD FINISH"

→ *from Page 45*

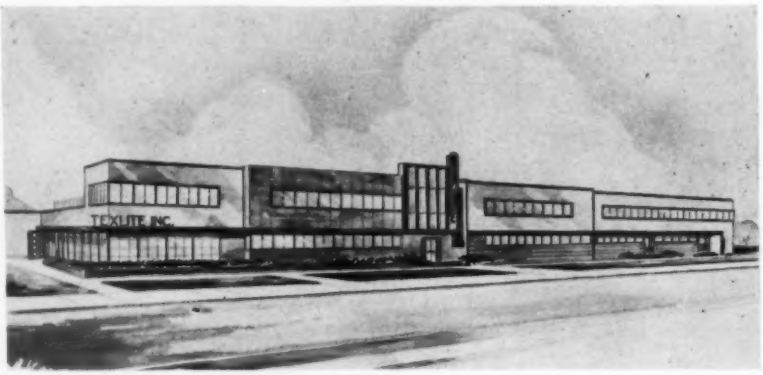
of Federal Enameling and Stamping Co., Pittsburgh, in which the carnival theme was used.

It was obvious that the trend among exhibitors was to get back to "selling" their merchandise. More genuine effort and care had obviously been used in the development of the merchandise displays than would have been experienced in earlier exhibits.

It seems evident that the demand for all types of appliances and housewares is still unprecedented, but there is growing acknowledgment of the fact that quality and value must be built into products for ready acceptance by the buying public.

Another important factor which will enter into a continued volume of sales is the speeding up of home building.

Texlite building million dollar sign plant



H. H. Wineburgh, president of Texlite, Inc., Dallas, Texas, has announced that construction has been started on a new streamlined plant on a landscaped 5.3 acre tract on Manor Way in the Love Field area of Dallas.

The 115,000 square foot building will house a two-story office section and a one-story factory capable of doubling capacity of present facilities. The factory will consist of three major sections: the sheet metal and fabricating department, the porcelain enamel processing plant, and the neon department.

A 54,000 square foot area will house the porcelain enameling facilities. This section will include a 105 ft. long continuous furnace with a firing chamber 3′ 6″ wide by 7′ high. Automatic spray equipment and tunnel type driers will be used. Almost one-half mile of continuous conveyors will serve the plant. Box-type furnaces now in use will also be retained.

In the brushing room, down-draft tables and vacuum-brushing will be used. The company will also produce its own screens for intricate sign work.

While signs are the principal Texlite product, the company also builds complete store and theater fronts, and is currently filling large orders for kitchen sinks.

Buchanan to Norris Stamping

It is reported that John C. Buchanan, formerly manager of the Norge Division plant at Muskegon Heights, Mich., resigned to take a position as a manufacturing executive with Norris Stamping & Mfg. Co., Los Angeles.

New Norge factory manager

O. H. Shenstone has been appointed Norge factory manager in charge of three of the company's refrigerator plants, according to an announcement by Howard E. Blook, president of the Norge Division of Borg-Warner. Shenstone has been with the company since 1942, when he was appointed manager of the Norge Machine Products plant in Muskegon, Michigan.

At the same time, Mr. Blood announced that G. P. Kennedy has been named resident manager of the Muskegon Heights factory. Kennedy is a veteran of 16 years' experience with Norge, and has served in capacities of chief inspector, resident engineer, general superintendent, chief tool engineer and assistant plant manager.

New Connecticut plant

Brennan-Shea Enameling Company, Sheridan and Seymour Streets, represents the name and address of a porcelain enameling company recently organized at Stratford, Connecticut. F. G. Brennan is president.

It is reported that the company will serve as a jobbing plant for the production of cast iron enameling.

Young to head Ferro Chemical Detroit office

The Ferro Chemical Corporation, Cleveland, Ohio, announces the appointment of Don A. Young as manager of its branch office in Detroit, Mich.

Edwin M. Ott, chemical engineer in the market research department of the Pennsylvania Salt Manufacturing Company, has been named assistant manager of market research, George T. Collins, manager, announced.

Seeger wins packing contest

A wirebound wood crate used by the Seeger Refrigerator Co. to carry refrigerator condenser units from its Evansville, Ind., factory won the first prize blue ribbon, emblematic of outstanding excellence among shipping containers, at the Protective Packaging Contest in Chicago recently.

James Cronk assumes position as ceramic engineer at Roper

The report comes from Geo. D. Roper Corporation, Rockford, Illinois, that James Cronk took over the duties of ceramic engineer in the company's porcelain enameling division on May 15.

Mr. Cronk is a graduate of Purdue University, with a Master's degree in chemical engineering. He was with Roper for several years previous to the war, and during the war he served with the Chemical Warfare Service in

• Reprinted from January "finish"

Pressurized Room for white coat spraying. One phase of the KOCH porcelain enamel finishing system for a southern manufacturer.

another

HIGH-PRODUCTION FINISHING SYSTEM DESIGNED BUILT and INSTALLED by KOCH ENGINEERS

This leading southern metal fabricator employed GEORGE KOCH SONS' complete service — engineering, fabrication and installation — to boost production and lower operating costs.

This single responsibility—from initial planning to final installation—affords maximum efficiency of operation at a nominal cost.

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Branch offices in most industrial centers.

the Pacific theater.

In assuming his new position, Cronk replaces W. L. (Bill) Donaldson, who left Roper on May 15 for a connection with Chicago Vitreous Enamel Product Company.

Washer-ironer sales still skyrocketing

Sales of household washers and ironers in the first quarter of 1947 broke all records and surpassed some previous highs by as much as four to one, or more, according to industry-wide figures announced by the American Washer and Ironer Manufacturers' Association.

Washer sales in the opening quarter of 1947 were 835,468, compared to 309,735 in the same period of 1946, an increase of 170 per cent and the largest of any consecutive three months period in history.

Ironer sales in the opening quarter of 1947 were 113,190, compared to 19,552 in the same period of 1946, an advance of 478 per cent.

A new Field

A report comes to *finish* of the arrival of a son, Charles Frederic, at the home of the C. N. Fields in Westchester, Illinois. "Chuck" Field is export and traffic manager at Chicago Vitreous Enamel Product Co.

Jean Clarke Thompson to direct domestic gas equipment publicity

H. Carl Wolf, managing director, announces the appointment of Jean Clarke Thompson to the Publicity Bureau of the American Gas Asso-ation to direct all domestic gas equipment publicity and services covering the use of gas equipment in homes for national magazines, women's pages of newspapers and women's radio programs.

Hoenigmann resigns from Florence Stove

Frank J. Hoenigmann has resigned as executive vice president and director of Florence Stove Co., according to company president Robert L. Fowler.

Bendix appoints chief engineer

John Paul Jones, Marion, Ohio, has been appointed chief engineer at Bendix Home Appliances, Inc., South Bend, Ind., according to W. F. Oliver, vice president and director of engineering. Oliver had held the post, in

CHECK YOUR THERMOSTAT NEEDS

1 DOUBLE POLE, SINGLE-THROW THERMOSTATS with direct or reverse action

2 COMBINATION THERMOSTATS WITH SELECTOR SWITCH and automatic cut-off of pre-heat

3 COMBINATION THERMOSTATS with limiting switch, automatic over-temperature cut-out, manual reset

No separate "off" switches are needed with Robertshaw direct acting Electric Thermostats. They have the Robertshaw exclusive mechanical, non-fatiguing snap-action actuated by a powerful hydraulic expansion element. When the temperature rises, contact arms are forced away from contacts by a powerful positive snap-action which produces instant, clean break of circuit. Mechanism is extremely sensitive and accurate to very close differentials.

Long life and dependability are insured by contacts and contact bridges of fine silver, hardened steel levers and supports, stainless steel diaphragm, and bakelite insulators. Snap-on dials permit temperature adjustments to be made without removing control from mounting box.

Other Robertshaw models for a wide variety of commercial, light industrial and home appliance uses are available.

Write for bulletins and complete information.

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THERMOSTAT COMPANY
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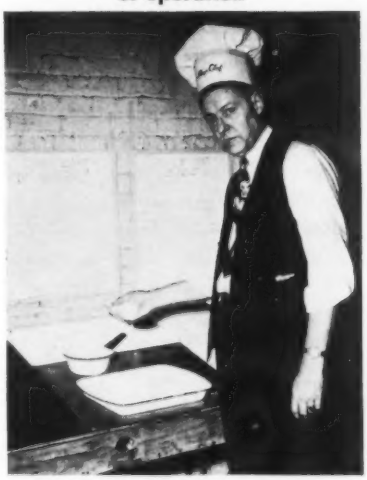
connection with his administrative duties, since World War II.

Jones joined the company after more than six years with various subsidiaries of International Detrola Corporation. He received his schooling in mechanical engineering at the University of Illinois.

Harvey Division, American Stove Co., celebrates half a century of operation



Ferd W. Rozene, general foreman of finishing at the Harvey plant, shows part of display for explaining the application of porcelain enamel.

Over twelve hundred well wishers attended the 50th anniversary celebration of the Harvey Division of American Stove Company at its plant on May 10. This was preceded by a Golden Jubilee celebration on Friday evening in a high school auditorium, where the program included such speakers as Arthur Stockstrom, company president; Harold Isaac, Harvey Division manager; Arthur Turngren, mayor of Harvey; Henry Piel, president, Harvey Assoc. of Commerce; Robert Clark, former division manager; and other key plant men and executives.

Saturday's Open House included a trip through the manufacturing plant.

Highlight of the trip through the plant was a demonstration of the porcelain enameling procedure, in which key operations were running, to show clearly the method of applying the finish. An accompanying display showed stove parts from raw metal

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PICKLE ROOM *Efficiency*
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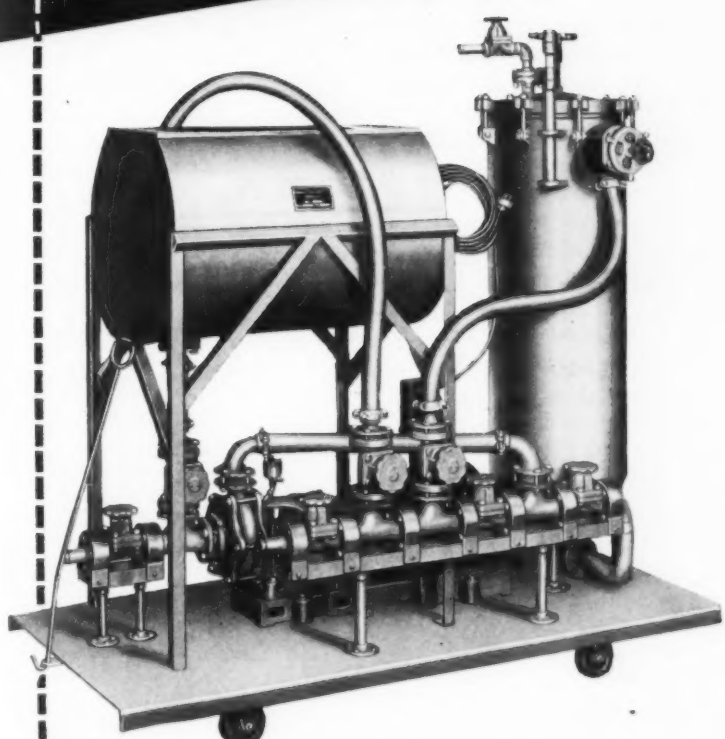

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→ *from Page 41*

flectance, but does not affect the color of the fired enamel.

A titanium enamel which exhibited excellent reflectance, acid resistance, and firing characteristics has the composition shown in the accompanying table.

Spectrophotometric analyses of the titanium enamels show a characteristic low reflectance near the violet end of the visible spectrum, differing in this respect from super-opaque antimony and zirconia enamels. Some differences in the spectrophotometer curves were noted over the field of enamels investigated, but the only major change in color occurred when even minute amounts of Cr_2O_3 were present. Additions of as much as 0.5 per cent Fe_2O_3 and 0.2 per cent V_2O_5 to the titanium enamel did not cause any appreciable variations in color.

X-ray diffraction patterns of enamels were made using slivers of the fired enamel as the specimens in the Hull-Debye-Scherrer powder method. The crystals causing opacity were either rutile or anatase; in the large majority of cases rutile was found. The reason for the re-crystallization of anatase in one enamel and rutile in another was not determined.

AH5J5 Enamel
Batch Composition

Feldspar	4.0
Borax	28.6
Quartz	38.7
Soda Nitre	3.1
Cryolite	6.5
Sodium Antimonate	0.2
Titania	12.2
Aluminum Hydroxide	1.0
Zinc Oxide	0.8
Magnesium Carbonate	3.4
Whiting	1.5
Smelting Temperature	2150° F.

Mill Additions

Frit	100
Clay	5
Titania	1
Bentonite	¼
Potassium Carbonate	¼
Sodium Nitrite	⅛
Water	40
Fineness	6-8% on 200 mesh
Firing	1540° F - 4 minutes

Evaluating adherence of blue sheet iron ground coat

By J. L. McLaughlin

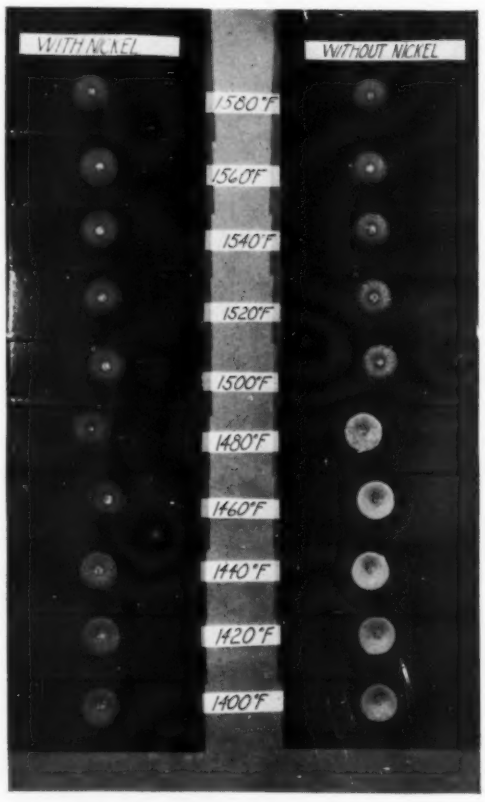
The adherence of blue sheet iron ground coats is evaluated by measuring the reflectance at the impact break by means of the Hunter multipurpose reflectometer and expressing this measurement as per cent apparent adherence.

The pieces were tested for adherence by the drop hammer method. A uniform force was obtained by dropping a weight from a fixed height on to a cylinder which forced a ½" steel ball onto the enamel panel, and this in turn was forced into a concave die.

As the degree of adherence lessened, the reflectance of the impact area increased until it reached an optimum when the entire area was devoid of enamel. For the sake of simplicity, it has been assumed that the change in reflectance is inversely proportional to the amount of enamel remaining on the impact area.

Essentially the plan is to establish reflectance values which represent zero and 100% adherence. The reflectance reading of the impacted area of any specimen indicates where this particular panel falls between the zero and 100% adherence limits.

The zero adherence value was determined experimentally from observation. The 100% adherence value was taken as being the reflectance of the ground coat before it was impact tested. The zero value was considered constant while the 100% value had to be determined for each panel, as difference in color due to the amount of fire or due to different frit mixtures will affect the reflectance even after impact testing.



Test panels show appearance of impact test areas. Note complete lack of adherence in panels in lower right hand corner.

Varying degrees of adherence with two types of metal surface preparation were provided for evaluation by

pickling one series of test plates with nickel dip and one without, and firing individual panels over a range of temperatures keeping firing time constant. The accompanying figure indicates the pickle procedure, firing temperature and the calculated apparent per cent adherence.

The system evolved here has certain advantages and conveniences not yet obtained in other methods of evaluating adherence, and since it agrees with the visual appraisal of adherence by experienced enamelers, it is felt that with appropriate modifications it might become a worth while test standard.

Industrial utility of porcelain enamel

By JAMES B. WILLIS

The general public has for many years thought of porcelain enamel as a deluxe type of decorative finish, usually used in connection with household appliances and certain types of architectural installations. In fact, the general lack of knowledge of the material is even responsible for the conception that porcelain enamel is chiefly a white finish, despite the numerous multi-colored store fronts and signs with which the public is in daily contact. Since the product has greatly enhanced the beauty of such installations, as well as protected them, the fact that porcelain enamel is, first, an especially fine protective coating, and second, a decorative finish, has been largely lost sight of.

Due in a large measure to these general misconceptions, the industrial use of porcelain enamel as a protective coating did not receive the attention which it warranted until the acute problems incident to World War II made necessary protective coatings for industrial applications having requirements which could be fulfilled only by porcelain enamel. Engineers and designers faced with new problems are now turning to porcelain enamel and ceramic coatings as a possible solution to their problems, whereas, prior to the war, such applications would never have been given a great deal of consideration.

Unfortunately, most enamelers have been interested chiefly in the application of the material as a decorative coating, and have, with few exceptions, made very little effort to advance the use of the material industrially. It is believed, therefore, that a general discussion of some of the uses of porcelain enamel as an industrial coating may be of interest, and it is hoped that it may arouse more enthusiasm on the part of the enamelers in general for the cultivation of a large, lucrative, and — up to the present — practically neglected field for the use of porcelain enamel.

Although the original use of the material was purely as a decorative coating on items of jewelry, the first major uses of porcelain enamel on steel and iron appear to have been as protective coatings, rather than decorative coatings, and one of the earliest mass production uses of porcelain enamel was in the hollow ware field where the application made possible the use of pots and pans fabricated from sheet iron. The continued use of porcelain enamel by the hollow ware industry for decorating their products has probably caused the public to forget that, without the coating, the base would be useless as a utensil for food preparation. It is surprising, therefore, in view of the long history of porcelain enamel in this field, that there has not been a wider use of the material in the food manufacturing industry since porcelain enamel enjoys a great ease of cleaning and superior surface hardness characteristics.

The history of porcelain enamel in other industries closely parallels its history in the food industry in that its superiority as a protective coating has been demonstrated, and yet the use of the material as a protective finish has not expanded in proportion to its true value. One of the magazines devoted to the chemical industry recently published a comprehensive list of corrosion-resistant materials, specifying their resistance to the chemicals most widely used in the industry. It was interesting to note that, with the exception of strong hot alkali solutions and hydrofluoric acid, porcelain enamel—or so called "glass lined tanks"—were more versatile than almost any other corrosion-resistant material listed.

During the war a number of the smaller enameling companies began to fabricate and coat some of the smaller items of equipment used in the chemical industry as, for example, pipelines, valves and so forth. At least one of these smaller companies pioneered the application of porcelain enamel to a number of chemical industry uses which had never before been considered.

Some of the applications of porcelain enamel to the oil refining industry have shown great promise in reducing corrosion in various parts of the distillation equipment. In handling equipment, porcelain enamel can play a very important role if an effort is made to introduce the material properly. For example, it has been found that the application of porcelain enamel to coal shutes and package shutes greatly increases the life of the equipment, and, due to the smooth low-friction surface, increases the speed of handling as well. The use of porcelain enamel as a coating for conveyor buckets handling sand, wet clay, etc., has made possible the prolonged life of the equipment as well as increasing its efficiency. The life of the equipment may be greatly prolonged, not only due to the protection provided by the porcelain enamel but also due to the fact that, if the porcelain enamel is eventually worn through, the part can be blasted and re-enameled without difficulty.

Since porcelain enamel is fused on metal, its heat-resistant characteristics are far superior to those of other types of protective coatings, and it may be used on surfaces where the only other alternatives would involve the use of expensive special alloys.

World War II greatly advanced the use of porcelain in these fields. In steam boiler pre-heater parts and other similar installations, porcelain enamel presents a surface which is resistant to corrosion, abrasion and thermal shock.

In the metallurgical field, porcelain enamel found usage during the war years as a protective coating for aluminum melting pots, increasing the life of the equipment and decreasing chances of contamination through the solution of iron from the pot by the molten aluminum. Another interesting use for porcelain enamel in the metallurgical field was a coating of nitriding equipment. In this application, porcelain enamel protected metal handling equipment against deterioration and embrittlement, and made possible the manufacture of this equipment from ordinary iron rather than the use of special alloys.

In the automotive and aeronautical field, the value of porcelain enamel was very markedly demonstrated in the use of the material for the protection of exhaust manifolds, mufflers and similar parts which were in contact with hot exhaust gases, and such use was even extended to maritime equipment. Although the enamel industry as a whole does not appear to have recognized the value of its contribution, the accessory manufacturers have certainly acknowledged the savings realized incident to the reduced replacement of parts.

The use of enamel-type coatings on wire-wound resistors is well-known, and has been practiced for many years. The use of silicate glass coatings in the electrical industry is still in its infancy and awaits only the initiative and aggressiveness of the enamel industry for further developments. It is not the purpose of this writing to define in detail the characteristics of the materials used in industrial applications of porcelain enamel, nor to provide an elaborate description of the multitude of industrial uses to which porcelain enamel is already or may be put. Rather it is believed that if serious consideration were given the industrial utility of porcelain enamel by a greater number of people, a vast expansion in the field of application for porcelain enamels would result, and the enamel shop operator could realize a greater and more varied outlet.

Improvements in the button test for the determination of enamel frit fluidity

By EDWARD E. MARBAKER

The so-called "button test", suggested by C. J. Kinzie *(C. J. Kinzie, Jour. Amer. Ceram. Soc. 15 (6) 357-360 (1932))*, has been for a long time employed in the enamel industry as a simple and rapid method for determining the fluidity of enamel glasses. Pellets of finely divided frit, bonded with paraffin, are melted under arbitrarily selected time-temperature conditions on a ground-coated plate placed horizontally in the furnace; then, as shown in Figure 1, when the plate is tilted at a very steep angle and the heating is continued, the enamels flow down the inclined surface to form drop-shaped buttons whose dimensions are measures of the fluidity of the respective frits. The frit that forms the longest button has the highest degree of fluidity.

Because a standard frit is always used as a control in each test, variations in technique and firing conditions have not been considered very important. It was noted, however, that the buttons of standard frit often varied in dimensions from test to test, and in general appearance and texture, indicating departures from standard conditions. It seemed desirable to develop a more precise technique in order that more confidence might be placed in the results, especially where slight differences in fluidity might be in question. The operations involved in the procedure were therefore examined, and certain refinements were employed by which the accuracy of the test was improved.

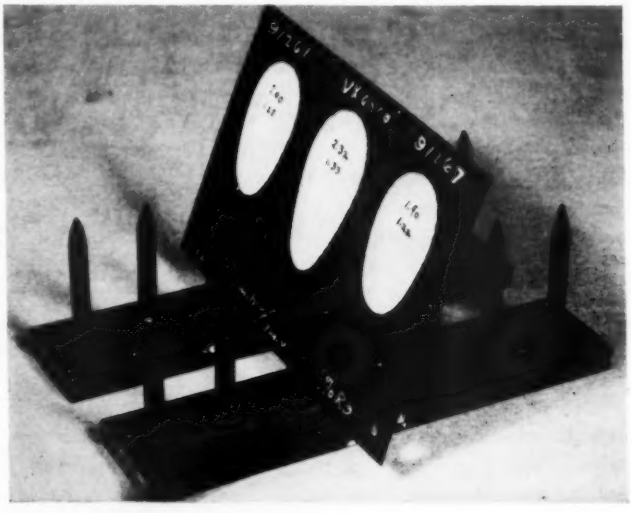


FIGURE 1 — *Photograph shows the shape of typical buttons when plate is in tilted position.*

Obviously the pellets must be uniform in size and texture, a result accomplished by standardizing the particle size of the frit, the kind and amount of binder used, and the molding technique. Excellent results were obtained by using as a binder a water dispersion of a starch product. Although drying of the pellets was thus required, the amount of binder could be controlled more accurately than when molten paraffin (the standard binder) was employed. The pellets must be heated under carefully controlled conditions. It was found that the heat distribution of the small Hoskins furnace used in making the tests was more uniform from side to side than it was from back to front, as

proved by the fact that more concordant results were obtained when the plates were heated in the transverse position.

Probably the most interesting observation made in the course of the investigation was that, for a given temperature, the length of the button can be controlled by the time of heating in the horizontal position. For instance, after tilting the plate, the enamel from a pellet heated for one minute had a longer flow than when a pellet of the same kind was heated for two or three minutes. The longer the time of horizontal heating, the shorter and wider was the button.

While it is not considered that this study has been completed, a technique has been worked out that leads to better reproducibility than the method now considered standard. The suggested procedure is as follows:

1. The frit powder is screened to —60 +90 size, and fines are completely removed by shaking the sieves for 10 minutes.

2. The weighed powder (2.1 gms.) is bonded with 0.75 ml. (13 drops) of a 0.5% dispersion of Corn Products R 9 in distilled water.

3. The spatulated mix is placed in the cavity of the mold, leveled off, and then the mold is inverted and the plunger tapped lightly with a hammer, until a stop on the plunger is brought into contact with the top of the mold. This procedure insures pellets of uniform dimensions and structure.

4. The pellets are evenly spaced on a 6-in. x 4-in. ground-coated plate and dried at 120° C. for 10 minutes in an oven.

5. The plate is placed transversely as far back in the furnace as convenient and heated for 3 minutes at 1600° F.

6. The plate is then taken from the furnace and turned in the points to an angle of 65°, replaced in the furnace with the buttons facing the back of the furnace, and heated for 7 minutes at 1600° F. (Figure 1). The clock is started when the furnace door is closed.

7. The plate is taken from the furnace, allowed to cool, and the length and width of the buttons are measured with an engineer's scale in tenths of inches estimating to 0.01 in., to determine the extent of flow and therefore the fluidity of the frit.

The technique of the button test should be subjected to further study and finally standardized for the enamel industry. This work should be carried out by the cooperative effort of the members of a committee.

Fundamental aspects of metal cleaning

By Jay C. Harris

An arbitrary classification of the variables involved in metal cleaning are defined as: (a) metal surfaces involved, (b) soiling agents encountered, (c) attracting forces involved, (d) "neutralization" of these forces, (e) materials for "neutralization", and (f) methods for soil removal.

The metal surfaces to be cleansed possess chemical reactivity, susceptibility to reactivity by reason of chemical coating or "condition", and a very definite physical condition which influences ease of soil removal.

Soiling agents are arbitrarily classified as inert, hydrophilic or hydrophobic, and the ease of removal of each type of agent is discussed.

There is an attraction of the soil for the metal surface and these forces are discussed in view of "neutralization" of such forces, and the materials potentially suitable for bringing about soil removal.

The actual methods for soil removal are varied, and combinations of them may be chosen to provide optimum soil removal for subsequent processing, the demands of which will vary.

A new method for studying fractures of porcelain enameled specimens

By F. A. Petersen, Rodney A. Jones and A. W. Allen

In most previous investigations dealing with the fracture of porcelain enamel applied to metal specimens, failure, under impact, thermal shock, bending or torsion, has been considered to have taken place when visible fracturing and removal of pieces of enamel occurs. By the use of "Statiflux", a commercial powder dusting technique, it is shown quite definitely that failure occurs in two stages. The first stage consists of the formation of extremely fine cracks in the enamel surface. These initial cracks are not visible even with the aid of dyes and microscopic observation, and are not detrimental to the serviceability of the object as far as most applications are concerned.

Under the technique described, these cracks are clearly delineated due to the alignment of a black, or white, electrostatically charged powder along any cracks which are open to the surface. The development of a system of microscopic cracks in the enamel may be an indication of subsequent service failure, the second stage in the failure process. It is fairly evident that in order to satisfactorily study enamel failures, and thus be in a position to develop better enamels, all phases of the failure must be considered.

On the basis of information obtained in this study it appears that by the use of "Statiflux" for crack delineation, much valuable information can be obtained as to the occurrence of the initial minute cracks and as to the stress systems which produced these cracks. Additional information concerning the relative magnitude of the stresses producing failure and the character and size of the initial cracks themselves must be obtained to have a concise understanding of the problem. Much of this

additional information can be obtained from a mechanical-mathematical treatment of the problem and by the use of surface replicas for microscopic or electron microscopic examination. Satisfactory reproduction of some of the "larger" cracks for microscopic observation and measurement was obtained by use of a commercial replica film process. Preliminary measurements indicate that the displacement of the surfaces of these fine cracks is in the order of 1 micron or less and that organic materials do not penetrate into them.

What type of porcelain enamel research is desirable?

Discussion: E. E. BRYANT presiding

It was pointed out that testing and standard tests are prime considerations being studied by the Enameled Utensil Manufacturers Council, Universities and commercial laboratories. Types of research in progress include: (1) coatings for high temperature resistance, (2) low coefficient enamels, (3) use of remilled enamel, and (4) development of standard tests.

Type of research needed

What research or what information do we need, or how can it be accomplished? F. A. PETERSEN: A test used but not completely worked out is the one to indicate and evaluate resistance to abrasion. The Tabor Abrasor is a good test. One drawback is slight variations obtained when testing a series of resistant enamels; greater differences are desirable.

W. N. HARRISON: Review of abrasion tests could lead to a better standard test or set of tests.

G. H. MCINTYRE: Enamels may be used under false conditions that make them look bad, and this is capitalized by competitors. Must consider service conditions when devising tests.

Other tests needed

F. A. PETERSEN: Tests for possible effect of different types of water and mild alkalis on porcelain enameled ware . . . . stress analysis of enameled parts . . . . tests for adherence and for evaluating adherence.

W. A. DERINGER: Mentioned McLaughlin's paper. Stated that there is a need to determine significance of adherence.

EDWARD MACKASEK: Fundamental research is needed. Put known facts together to get the answer to problem of adherence. Competition is going to cut in if we do not follow up on fundamental research, particularly with regard to adherence.

E. E. BRYANT: In the past, the enameling industry has developed a theory and tried to prove it. It would be better to obtain facts, and then develop theory.

The authors' resumés of papers presented to the Enamel Division at the American Ceramic Society meeting are presented in accordance with the publication policy of the American Ceramic Society. Complete papers will be published in the Journal of the A.C.S., the A.C.S. Bulletin, or in other industry publications as released by the Society.

Space does not permit the presentation of all available resumés in this issue. Additional papers will be represented in the July issue.

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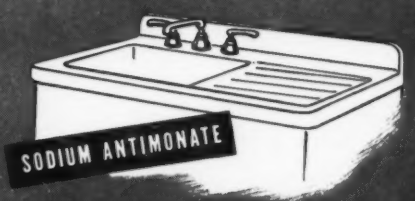

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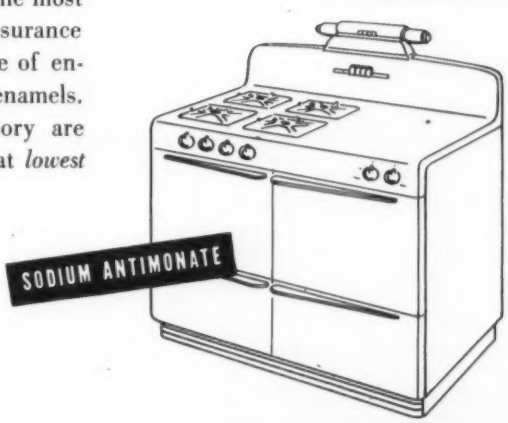

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The social get together and dinner was followed by an elaborate entertainment program under the chairmanship of Ed Bolin, of Chicago Vitreous Enamel Product Co., and secretary and treasurer of the Club.

Thirty or more carefully selected door prizes were presented as a feature of the evening.

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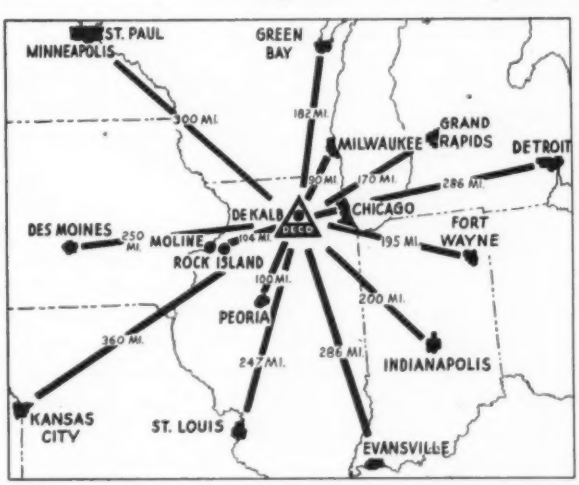

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Lithium compounds in porcelain enamel compositions

(Continued from Page 21)

addition of 2% lithium manganite to the mill, and no fishscale or shiners whatsoever appeared on the same type of articles and steel gauges. This test, at the same time, was a good proof that lithium manganite can replace a considerable part of adherent oxides of the traditional type.

Rather impressing seems to be the influence of lithium compounds in general. Falling weight tests showed almost no traces of enamel shattering on either the lithium-bearing ground coat or the finish coat.

Further investigations of the character of the bond of lithium-bearing enamels seem to be advisable as it has the appearance that lithium somehow changes the mechanics of the adherence. This is most important as, in spite of all the numerous studies on this subject, our lack of basic knowledge of "bond" in general has to be admitted.

In spite of improved adherence, no remarkable improvements in impact shock resistance by using the E.U.M.C. impact test could be noticed. It should, however, be mentioned that the impact shock resistance was not reduced, in spite of the thin application of the lithium ground coat.

It is known from past work[7] that greater enamel thickness secures better impact shock resistance on porcelain enameled cooking utensils. It seems, however, that variations in thickness of the cover coat is of far greater influence in this respect than is the thickness of the ground coat.

---

(1) Ceramic Industry, p. 96 (January, 1945).

(2) "Enamel Bibliography," American Ceramic Society (1944).

(3) Waterton and Turner, Journal Society Glass Technology, *18* (1934).

(4) A. I. Andrews, "Enamels," Twin City Printing Co., p. 30 (1935).

(5) Karl Kautz, "Molybdenum in Enamels" Part II, Journal American Ceramic Society, *25*, 6 (March 1942).

(6) Published by Julius Springer, Berlin (1929).

(7) R. L. Fellows, "Relation of Thickness of Enamels to Impact Shock Resistance of Porcelain Enamels," Journal American Ceramic Society, 26, 160-62, 1943 — and — F. A. Petersen and A. I. Andrews, "Relation of Metal Thickness, Enamel Thickness, and Bottom Radius, to Impact Resistance of Porcelain Enameled Utensils," ibid. 28, 102-10, 1944.

Porcelain enameled air marker gets national attention

(Continued from Page 24)

D. C., was introduced by Major Lucas as "a flier who has a great many laurels to her credit." In her talk, Blanche Noyes said: "*It is a privilege and a pleasure to be present at the dedication of the finest air marker in these United States. It is one which is permanent and will last — not for a day, not for a week, not for a year, but last forever. I have, for a long time, been an advocate of the porcelain enameling of markers,* and this is the first one for which I have had the privilege of being present at the dedication.

"I would like to say that air marking is the most necessary adjunct to the safety of non-scheduled flying. An air marker is to the pilot what a route sign is to the motorist.

"Recently there have been a number of crashes which could have been averted by what you have on top of the building which I am now facing — an air marker. So, ladies and gentlemen, this marker on the roof not only advertises your city, but it is also a life saver. I only hope that all of your surrounding cities will take up your example and put in bigger and better air markers."

Lt. Col. Gordon DeCosta, Wing Commander of the C.A.P., spoke on his organization's program. "There has been a program in C.A.P. to help air mark all of the cities in the State of Illinois. It's a very important project, and many organizations have been cooperating in that program. We are very pleased to work with them in promoting that phase of aviation. . . . Every community should be vitally interested in aviation, as it plays a very important part, not only in your community here in Wheaton, but in the entire state and in the nation. . . .

"We are very pleased to be able to fly over a city and find that it is marked, and we can chart ourselves and know where we are. . . . I hope to find many more of them throughout the State of Illinois."

Dwight Green, governor of the State of Illinois, was represented through a letter read by Chairman Lucas which contained the following: "For your information, I am quite interested in the subject of adequate air markings for all the communities in our state, and at the first opportunity I will plan to examine the air marker at Wheaton from the air."

Merrill Meigs, managing director of the Herald American, chairman of the Chicago Aero Commission, and one of the directors of the Air Power League, a national organization which charters local Air Power Clubs, delivered greetings on behalf of the Mayor of Chicago and the Chicago Aero Club.

Other introductions from the speakers' platform included: Ronald Smith, aviation chairman, Illinois Jr. Association of Commerce; H. J. Burt, aviation chairman, Wheaton Lions Club; Paul A. Isherwood, County Aviation Committee, and O. B. Dold, engineer for the committee; George Petru, Art Karstens and F. L. L. Wilson, the roof owners; Howard Michel, Porcelain Enamel Specialties Company; Ralph Foraker, representing Pemco Corp.; Ed Seasholtz, J. M. Seasholtz & Sons, Inc.; Dana Chase, *finish;* Brig. Gen. Richard Smykal, of the Illinois National Guard, who arranged for plane flights; Lt. Col. Charles Richardson, executive officer, the Illinois Wing of C.A.P.; Capt. George Dunlap, C.A.P.; State Representative Jim White, who is credited with doing a great deal of work in promoting air markers; Gladys Snyder, of Rockford, who in 1946 won the Blanche Noyes Trophy for personally being responsible for placing more air markers than any other person in the United States.

Finish has carried a report of this air marker dedication in detail as it is hoped that interested porcelain enamel industry members in other parts of the country may be able to

to Page 64 →

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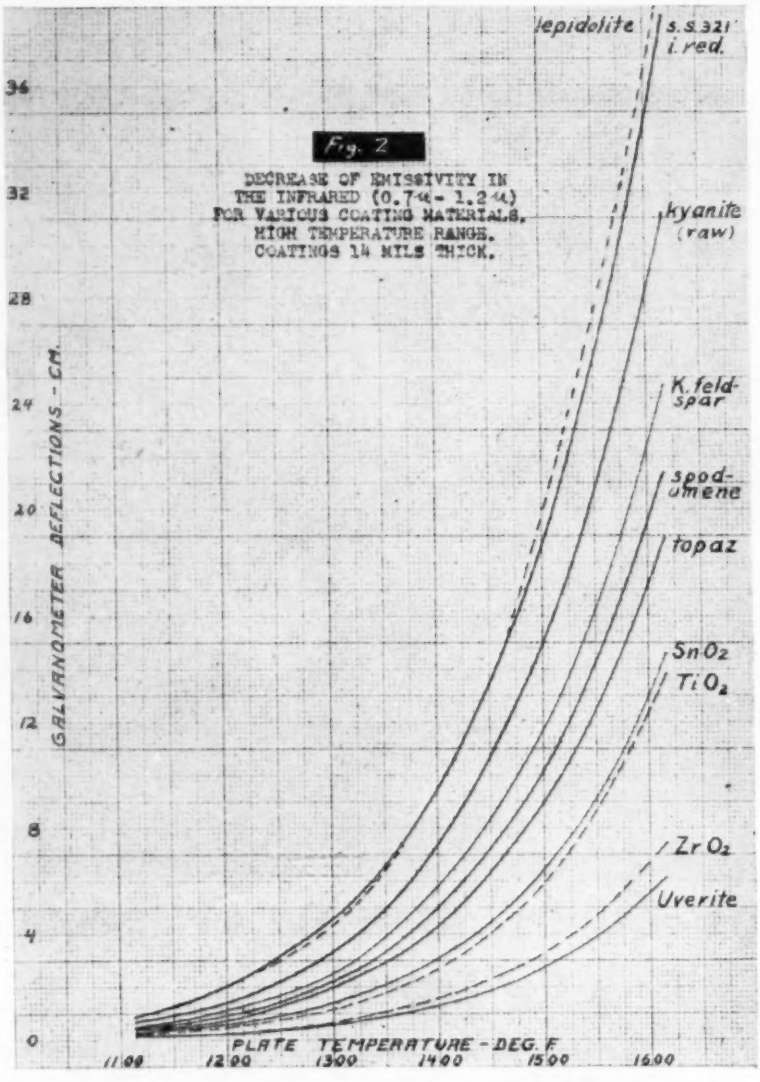


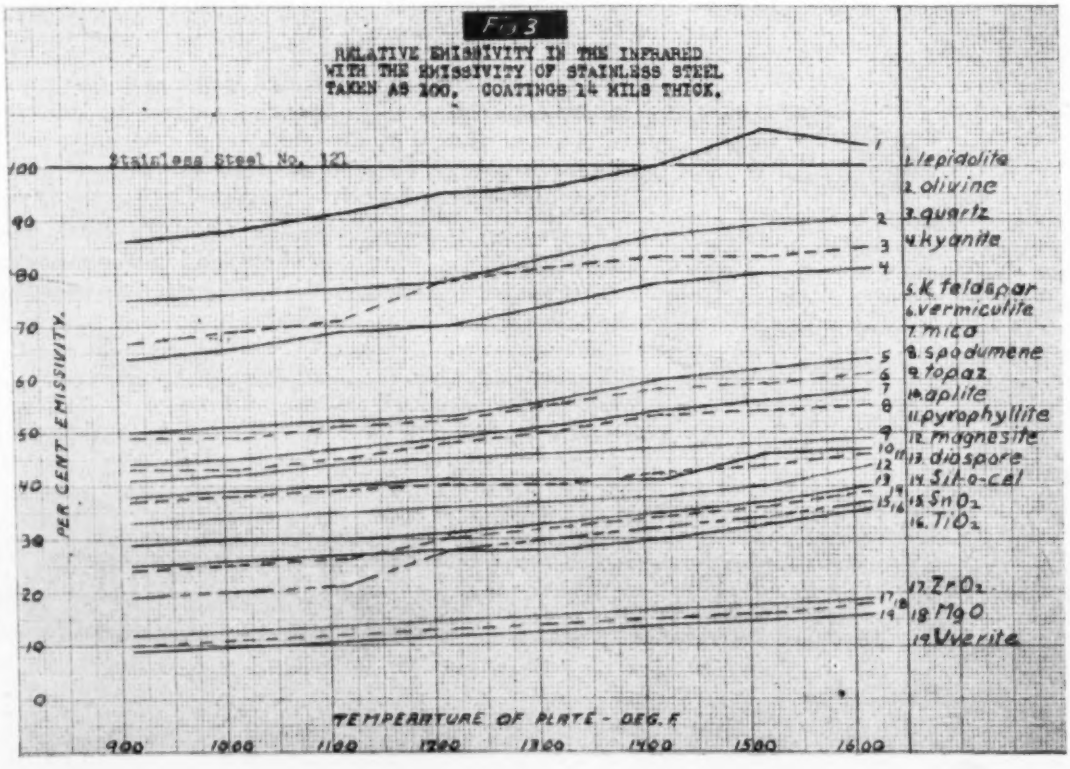
Suppression of radiations at high temperatures...

(Continued from Page 34)

The grouping of the curves shown in Figure 3 is of considerable significance. The highest curves, of lepidolite, olivine, quartz, and Kyanite, represent materials which might be used to coat metals for protection where uninterrupted heat flow is desired. The lowest curves, of Uverite, MgO, and ZrO_2, represent materials which would retain heat, a condition which is frequently desirable.

In this investigation numerous corollary data were obtained. These included the development of bonding glasses of low transmittance at high temperatures and determinations of effective practical coating thicknesses. It was found that by the use of selected thin coating films over a relatively thick coating of another material the emissivity could be sharply increased or decreased, apparently in accordance with the tendency of the film material to emit radiations at the given temperature.

Finally, high temperature resistant, air setting, ceramic paints of effective radiation suppressive properties were developed for either plant or field application as desired.



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